CHAPTER 10

THE INTENSIFIED SMALLPOX ERADICATION PROGRAMME, 1967–1980

Contents

INTRODUCTION

The prevention and ultimately the eradication of smallpox constituted, in principle, one of the simplest and most straightforward of disease control activities. Effective long-term protection was provided by the single application of a vaccine which was easy to administer and highly stable even under tropical conditions. The presence of smallpox in an area could be readily detected because of the characteristic rash it produced, a rash which was readily identifiable by programme staff and villagers alike. Only patients with rash transmitted the infection to others, and then only to persons with whom they were in close contact. Because 10–14 days elapsed between each generation of cases, smallpox usually did not spread rapidly and epidemics took time to develop. Little more was required to control its spread than the isolation of the patient and the vaccination of his close contacts.

Despite the simplicity of both smallpox control and the strategy for its eradication, implementation of practical field programmes over a finite time span and on a global scale was a complex and difficult task. The achievement of eradication and its certification ultimately required the cooperation of all countries. The participation of an international agency—the World Health Organization—was important, and probably essential, in ensuring such cooperation. As the international organization with technical responsibility for health programmes, WHO was requested by resolution WHA20.15 of the Twentieth World Health Assembly "to elaborate and implement the detailed plan, including the co-ordination of all international, bilateral and national efforts" for the Intensified Smallpox Eradication Programme (World Health Organization, 1973a). In carrying this out, however, WHO had no authority, other than that of moral suasion, to compel any country to initiate a programme, adhere to a plan or strategy, or contribute towards its support. For this reason, the global programme had to evolve within a framework of broad principles and expectations, pragmatically modified by reality, rather than within the confines of a comprehensive master plan having specific and enforceable time-limited goals.

In November 1967 the entire professional and secretarial staff of WHO throughout the world (including short-term consultants and

WHO agents in Zaire) numbered only 3302 persons, few indeed to cope with the array of tasks and responsibilities with which the Organization had been charged by the World Health Assembly, its governing body. Those assigned to smallpox eradication were likewise few in number, the staff of professional grade in no year comprising more than 150 persons (including consultants), of whom no more than 6 were in Headquarters and, at most, 7 in the WHO regional offices. They were expected to promote special programmes in more than 50 countries and to guide and coordinate activities which, at times, involved as many as 150 000 workers.

The programme presented unusual challenges for WHO, because the administrative structure and procedures of the Organization were primarily designed for the purpose of providing technical assistance, rather than material support, to a wide range of health projects in many different countries, few of which needed to be coordinated with others. Smallpox eradication, in contrast, required the provision of substantial material support and far closer collaboration among countries and among largely independent WHO regional offices, both in programme execution and in resource allocation.

The Director-General, Dr Marcolino Candau, had foreseen the need to mobilize substantial voluntary contributions in support of the programme but, in 1967, the Organization had had only limited experience and little success in obtaining contributions of this type. Significant donations for smallpox eradication—apart from some bilateral contributions—did not begin to be received by WHO until more than 7 years had elapsed. The consequent lack of resources constituted a serious, continuing problem and, even in the concluding years of the programme, those that were made available barely sufficed to sustain momentum. Donated vaccine, for example, was continually in short supply despite repeated appeals for assistance. The World Health Assembly was informed on a number of occasions of the need for additional funds, amounting to no more than a few million US dollars, and such funds were sought in correspondence and in meetings with potential donors, but the response was never adequate. Expenditures for smallpox eradication from WHO's own regular budget, measured in constant dollars, seldom exceeded US$2.4 million annually, the amount initially appropriated by the Nineteenth World Health Assembly in 1966. Thus, restraint and compromise in field operations were necessary even when global eradication appeared imminent. Success was never a certainty even during the years immediately preceding the last known cases.

The problems of sustaining international commitment and support were formidable but no less so than those in many of the countries with endemic smallpox. Successful national programmes required a political commitment to undertake eradication, but smallpox was not a concern of high priority for some countries, even though they might have voted for World Health Assembly resolutions in favour of its eradication. Sustaining a commitment to the programme was no less difficult because, in many countries, governments changed frequently, as did the responsible health officials, and such changes led to the readjustment of national priorities. Famine, flood, epidemic cholera and the like often diverted smallpox eradication programme resources for long periods; civil war in Ethiopia, Nigeria, Pakistan and Uganda caused serious disruptions in operations; and collaboration with several governments in southern Africa, as well as some in Asia, was all but impossible owing to political constraints.

After smallpox had been eradicated, however, many persons inside and outside WHO mistakenly concluded that the achievement could be attributed to a generously financed, enthusiastically supported and authoritatively directed programme similar to a military campaign. That the programme had none of these characteristics is apparent from this and the succeeding chapters.

This chapter describes the context within which the programme functioned in WHO and how the overall campaign developed and matured, how national programmes were established, how international coordination was achieved, how personnel were recruited and budgetary problems resolved, how supplies of vaccine were obtained and handled, and how research contributed to the effort. All these activities were interrelated, and critical constraints or important developments in one area affected progress in others. For clarity of presentation, different elements of the Intensified Programme are discussed individually, beginning with the overall strategic plan and the programme's administrative structure, relationships and personnel at the international level. This is followed by a

description of the way in which national governments became committed to the programme. A discussion of resources, surveillance and research, from an international perspective, is followed by a general description of the approaches adopted and results obtained in national programmes of vaccination and surveillance. To provide an overall perspective and an introduction to the chapters describing national programmes (Chapters 12–23) and certification activities (Chapters 24–27), a brief chronological summary of events concludes the chapter.

THE STRATEGIC PLAN

As described in the Director-General's report on smallpox eradication to the Nineteenth World Health Assembly (World Health Organization, 1966b), the strategic plan for eradication during the Intensified Programme was 2-pronged: (1) mass vaccination campaigns in which freeze-dried vaccine of assured quality was employed and which were assessed by special teams, and (2) the development of a surveillance system for the detection and investigation of cases and the containment of outbreaks. In the execution of the programme, 3 principles were considered to be of special importance: (1) all countries would need to participate and their efforts would require regional and global coordination; (2) flexibility and adaptability would be required in the implementation of national programmes; and (3) ongoing research, both in the field and in the laboratory, would be needed to evaluate progress, define alternative directions and methods, and solve problems as they arose.

To foster a common understanding of principles and procedures among a geographically far-flung programme staff, a comprehensive mimeographed manual entitled *Handbook for Smallpox Eradication Programmes in Endemic Areas*, hereafter referred to as the WHO Handbook, was issued by the Organization in July 1967 (SE/67.5 Rev. 1, World Health Organization). It was an elaboration and adaptation of a manual developed in 1966 for the programme supported by the USA in western and central Africa (see Chapter 17). The foreword to the WHO Handbook encouraged programme staff to innovate and to adapt as needed, since programmes should evolve and change with experience. For this reason, the WHO Handbook was deliberately referred to as a "draft", in the expectation that revised versions would be prepared in subsequent years on the basis of field experience. Because of the small number of staff available in Geneva and the speed with which the programme developed, no revised version was ever issued, other means being used for passing on from one country to another new and important observations and approaches. The WHO Handbook included a wide variety of information, ranging from an account of the clinical features of smallpox and the methods used in laboratory diagnosis to a description of operational approaches for vaccination campaigns and surveillance programmes; it also described methods for use in health education, and the management of administrative and transport services. The Handbook concluded with a section describing more than 20 subjects of interest for field and laboratory research.

The basic strategy, with certain modifications in emphasis and subsequent elaboration of methods for its implementation, withstood the test of field experience. Vaccination campaigns, however conducted, were expected to reach at least 80% of the population in all areas, and higher, but unspecified, rates of coverage in the more densely populated cities and towns. The figure of 80% was not based on any epidemiological criterion, but represented what was believed to be an achievable goal in a well-conducted programme. As an indicator of the use of potent vaccine, the plan called for a take rate of at least 95% for primary vaccinations. To determine whether these objectives were being met in a given area, independent assessment teams were expected to monitor the results in a sample of the population soon after the campaign had concluded in that area.

Although assessments of coverage and take rates were considered to be important quality control measures in the vaccination campaigns, the WHO Handbook emphasized that "the success of the programme, therefore, is appraised ultimately by the occurrence or absence of endemic smallpox and the *principal assessment technique, accordingly, is surveillance*". Surveillance was to be based on a reporting system in which all existing medical and health units participated. This was to be supplemented by the immediate investigation of reported cases and a critical review of outbreaks to determine how and why small-

pox was being spread. The WHO Handbook stated that:

"... surveillance thus is an essential component of the programme since the term 'eradication' implies that the number of indigenous cases of smallpox is '0'. However extensive a country's vaccination campaign, however accurately assessed, a country with an inadequate system for surveillance cannot determine whether ... eradication has been achieved."

Since it was recognized that surveillance was a new concept and might be difficult to implement in highly endemic countries, a phased programme for its development was proposed (see Chapter 17, Table 17.4).

Mass vaccination was a familiar and readily acceptable concept to public health officials. Assessment of the quality of work and of progress, on the other hand, had not been common practice. Few were accustomed to measuring the success of their efforts and many, in fact, had never questioned whether the vaccine in use was satisfactory or had been properly stored. Both assessment and surveillance proved difficult to incorporate into most programmes.

THE WORLD HEALTH ORGANIZATION

Among the international agencies, WHO has played a pre-eminent role and acquired substantial experience in providing technical assistance and cooperation for health programmes and in the development of international health policies. Other international agencies—e.g., UNICEF and the United Nations Development Programme—have provided substantial material assistance for health programmes, but WHO, from the time of its foundation, has seen its main task as that of providing technical guidance (Finkle & Crane, 1976). WHO, like all large administrations, has gradually evolved its own patterns and traditions of management and, while a full exposition of this subject is beyond the scope of this book, certain features are important to an understanding of the course of development of the global smallpox eradication programme.

In a comparative analysis of 8 major international organizations, Jacobson (1973) characterized the role of the Director-General of WHO as being unusually significant and influential. He described the Organization as a "strong and stable system", but noted that it was "dominated by the ideology of medicine" and "by a strong commitment to regionally decentralized service activities". Because of this decentralization of activities and responsibility within WHO, its regional directors have also played unusually important roles. They and the Director-General are the only elected officials of the Organization. If after a term of office of 4–5 years they wish to be reappointed, they must stand for re-election by Member States. The factor of re-election inevitably has a bearing on their decisions regarding the recommendation of projects, budgetary allocations to countries, appointment of staff by nationality, and other matters. Continuity of the elected leadership, however, has been the norm. Although the first Director-General, Dr Brock Chisholm, served for only 5 years (1948–1953), his successor, Dr Marcolino Candau, served for 20 years (1953–1973), and Dr Halfdan Mahler has held the office since that time. For most regional directors, a long term of office has likewise been the norm.

The Members and Governing Bodies of WHO

The World Health Assembly, which decides WHO's policies and programmes, consists of delegates representing Member States, each Member State having one vote. It normally meets once a year, usually in May. Guidance to the Health Assembly is provided by the Executive Board, a smaller body, whose members serve in a personal rather than an official capacity but are designated by the governments of Member States elected by the Health Assembly. The Board meets twice a year, the main meeting being held in January, while a second, shorter, meeting takes place immediately after the Health Assembly.

The Twelfth World Health Assembly (1959) and the Nineteenth World Health Assembly (1966) committed WHO to the global eradication of smallpox although some countries were not then Members of the Organization and hence not party to these decisions. Among those which, in 1966, were not yet Members or were not yet directly represented were the People's Republic of China, the German Democratic Republic, the Democratic People's Republic of Korea and the Socialist Republic of Viet Nam. Until the 1970s, no official communication between

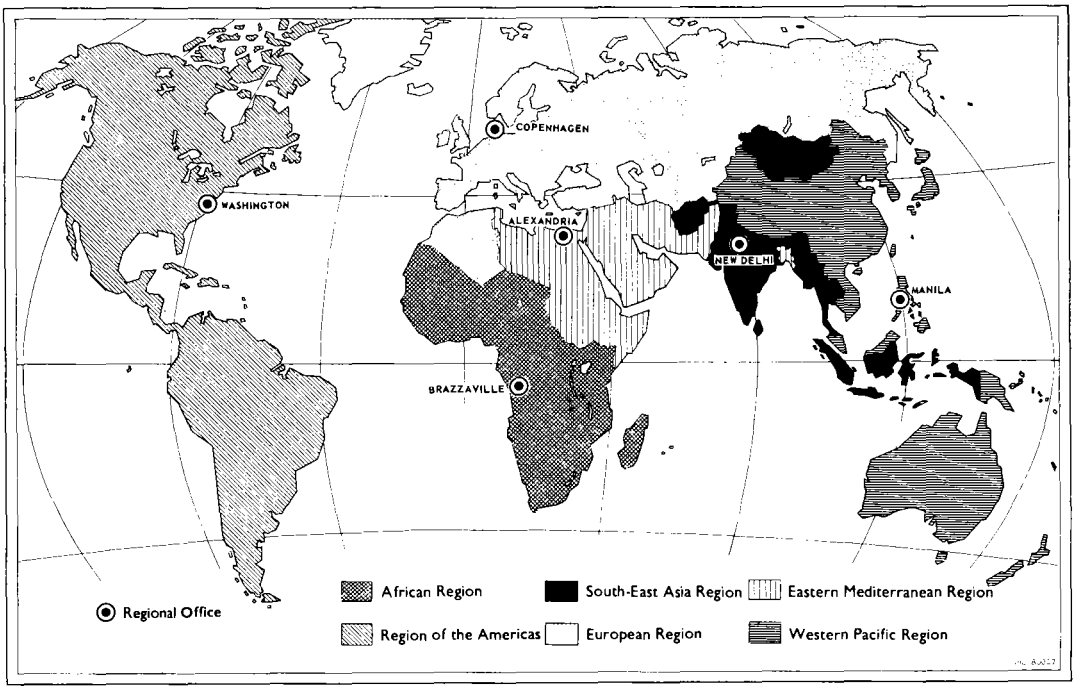

Fig. 10.1. WHO regional offices and the areas they served, December 1967. Whereas there were 167 Member States and Associate Members of WHO in December 1986, there were only 129 when this map was prepared (from World Health Organization, 1968a). A number of countries or territories shown here as served by WHO regional offices were not directly represented in WHO in 1967, the largest among them being the People's Republic of China.

WHO and these governments was possible and little official information was available from some of them about the status of smallpox in their countries. None was thought to have endemic smallpox in 1966, although it was not possible to confirm this until after they became Member States of the Organization. Besides these countries, there were 4 other large territories, all in Africa, which in 1966 either no longer participated in WHO (South Africa) or were represented by colonial powers (Angola, Mozambique, and Southern Rhodesia). All except Angola had endemic smallpox in 1967. Until the 1970s, however, it was difficult or impossible for WHO to communicate with these countries as well, either about the occurrence of smallpox or about the status of their programmes. Thus, effective universal participation in the smallpox eradication programme was not achieved until a number of years after the Intensified Programme had begun, and not until 1979 were communications adequate with all countries so that global eradication could be certified.

Each Member State is attached to one of WHO's 6 regions (Fig. 10.1), only 4 of which had endemic smallpox in 1967—Africa, the Americas, South-East Asia and the Eastern Mediterranean. Regional committees, at which Member States of the respective regions are represented, meet once a year to decide regional policy and to examine the regional director's proposed programme budget for transmission to the Director-General and inclusion in the Organization's global programme budget.

The type of representatives sent by Member States to the Health Assembly and the regional committees had a bearing on the smallpox eradication programme and on the outcome of resolutions. An analysis of delegates to the Twentieth World Health Assembly (1967) showed that 80% were representatives of health ministries (Jacobson, 1973); while that was logical and often advantageous, it was sometimes a handicap to obtaining voluntary contributions from governments and to securing national commitment to undertake eradication programmes. Volun-

tary contributions from the industrialized countries were usually provided by a development agency separate from the ministry of health and, as experience showed, liaison between the two was frequently deficient. Programme policies and needs identified by the World Health Assembly were often not understood by the development agencies and sometimes, because of this, appeals for voluntary contributions went unheeded. The way that the countries with endemic smallpox were represented also gave rise to problems. Ministries of health, to which most delegates belonged, were often politically weak, the minister often not being of cabinet rank. Decisions with regard to the allocation of national resources were often made elsewhere in government—e.g., in planning departments, few of whose members attended the World Health Assembly. Thus, the commitment of some Health Assembly delegates to undertake national programmes meant little from the point of view of their implementation.

Role of the Director-General

Decisions on policy and budgetary allocations were ultimately the responsibility of the Health Assembly, acting on the advice of the Executive Board but, as Jacobson (1973) points out:

> "The Director-General initiates the process of formulating WHO's budget and establishes guidelines ... Later he compiles the proposals of the headquarters staff and the regional offices. At both stages he has opportunities to make important judgments about allocations among functions and regions. The formal position of the Director-General makes him an initiator, controller and vetoer as far as programmatic decisions are concerned."

The minutely detailed budgets proposed by the Director-General were seldom altered either by the Board or by the Health Assembly; moreover, after they had been approved, he had considerable discretionary authority to transfer funds from one programme to another and from country to country as need and opportunity dictated.

Changes in WHO policies were less likely to be impeded by long-established career staff than in many other large administrations. Relatively few had career service appointments in comparison with some other international organizations. From the time of WHO's foundation, a continuing turnover of personnel had been considered helpful in sustaining a high level of professional expertise. Thus, in 1969, only 20% of professional staff at Headquarters and the regional offices and about 5% of those working in field projects had career service appointments (Jacobson, 1973). In the same year, only 29% of the staff had served in WHO for more than 5 years.

For these reasons, WHO's limited financial support for smallpox eradication prior to 1967 (see Chapter 9) reflected the concerns and priorities of the Director-General at least as much as those of the Health Assembly. His attitude in turn reflected, in large measure, his scepticism as to the possibility of achieving global smallpox eradication until basic health services in all countries had been greatly strengthened, a scepticism shared by many scientists and health officials at that time. His doubts had been reinforced by the recommendation of the WHO Expert Committee on Smallpox (1964), discussed in the preceding chapter, which implied that everyone would have to be vaccinated to ensure eradication. Since, for example, there were tribes in the Amazon basin with which national authorities had little or no contact, it was apparent that universal vaccination was not then possible. For the Organization to be committed to an unattainable objective when, at the same time, its only other global eradication programme—that for malaria—was in serious difficulty, could jeopardize WHO's technical credibility. Moreover, the Director-General foresaw the possibility of another single-purpose eradication programme diverting national and international resources and attention from the important, but difficult and less glamorous, task of developing basic health services. He frequently pointed out that, if additional funds were to be allocated to smallpox control, they should be provided in the form of voluntary contributions by the industrialized countries, which would benefit by having fewer imported cases of the disease to deal with.

The decision, in 1966, by the Nineteenth World Health Assembly to establish a special allocation for smallpox eradication in the Organization's regular budget required WHO to undertake a more vigorous programme, but the additional funds did not allay the Director-General's concerns about the Intensified Programme's prospects of success.

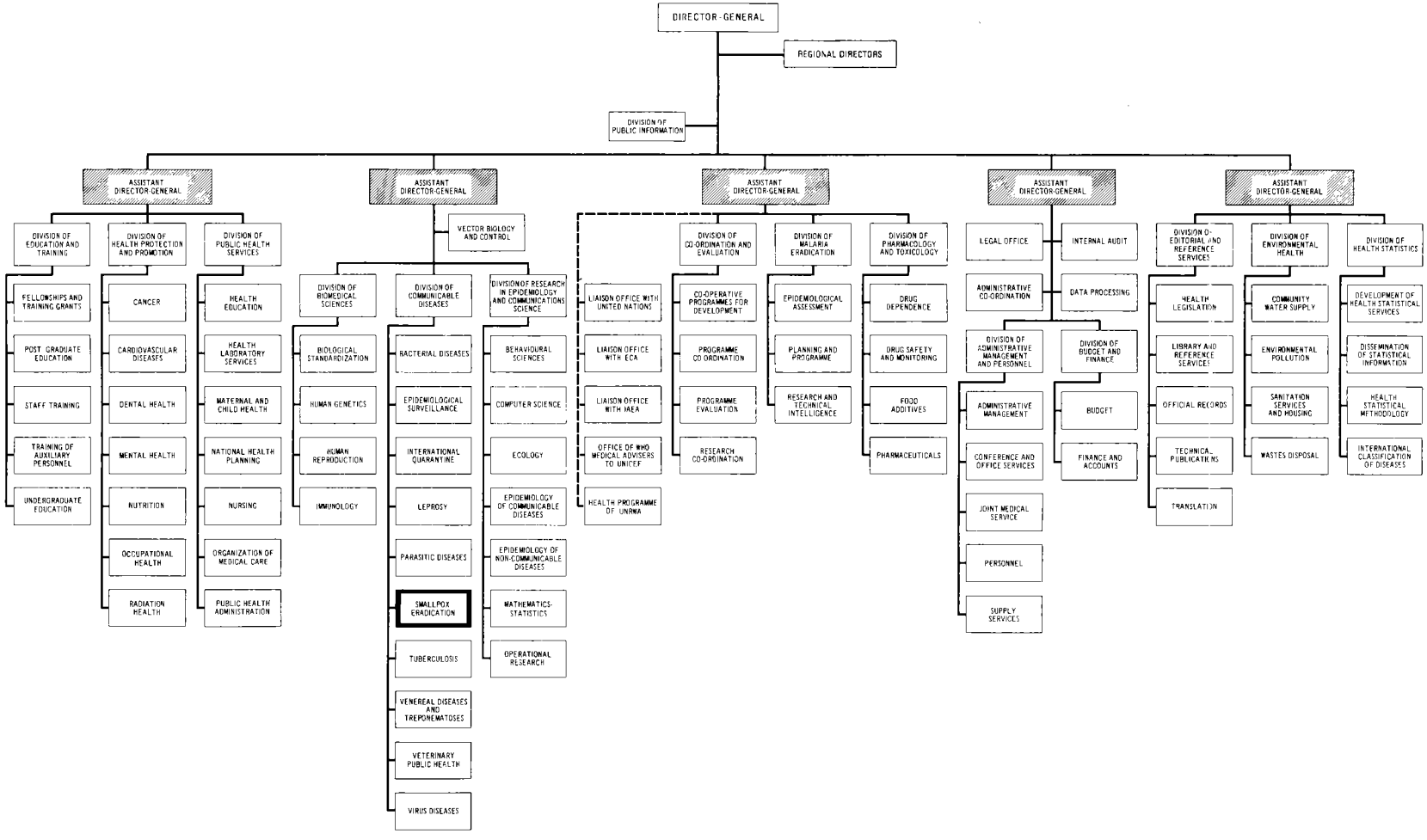

Fig. 10.2. Organizational structure of WHO Headquarters, December 1967.

Plate 10.1. Halfdan T. Mahler (b. 1923) took office as Director-General of WHO in July 1973. His long career in international public health had included almost 10 years as a senior WHO officer with the Indian national tuberculosis programme. This involved the application of methods of operations research that proved valuable when, as Chief of the WHO Tuberculosis unit, 1962–1969, he worked with the Smallpox Eradication unit to overcome the problems of the simultaneous administration of BCG and smallpox vaccines. He had been an Assistant Director-General of WHO from 1970.

WHO Programme Management in Geneva

The management and supervision of technical programmes at WHO Headquarters differed from what an organizational chart (Fig. 10.2) might suggest, as is indeed the case with many organizations. During Dr Candau's term of office as Director-General, technical programmes at WHO Headquarters were usually monitored by the Director-General and the Deputy Director-General, Dr Pierre Dorolle, through direct contact with the chiefs of the respective technical units. The senior intermediate positions in this inter-governmental organization—assistant directors-general and directors of divisions—had many representational duties and were often relatively little concerned with the day-to-day activities of the technical units. Over the 20-year period during which Dr Candau was Director-General, the Organization grew in size and the number of activities and technical units multiplied, making direct supervision of each of them increasingly difficult. Smallpox eradication programme staff seldom met the Director-General until Dr Halfdan Mahler assumed the post in 1973. Contacts with the responsible assistant director-general were likewise uncommon before Ladnyi's appointment to this position in 1976. Among those who served as directors of the Division of Communicable Diseases, Dr Karel Raška, who held this post until early 1970, took a particular interest in smallpox eradication and actively supported the programme.

The Smallpox Eradication unit had, of necessity, a closer, continuing relationship with those responsible for WHO's administration and finance. Until 1971, the Assistant Director-General responsible for this area, Mr Milton P. Siegel, an active proponent of smallpox eradication, directed these activities and those reporting to him took a similar interest in the programme. Both during and after his period of tenure, most of them went out of their way to provide help and guidance.

Throughout much of the smallpox eradication programme, the unit, as far as the management of its technical activities was concerned, functioned relatively autonomously. This meant that it could alter smallpox programme policies and make other decisions quickly, but it made it more

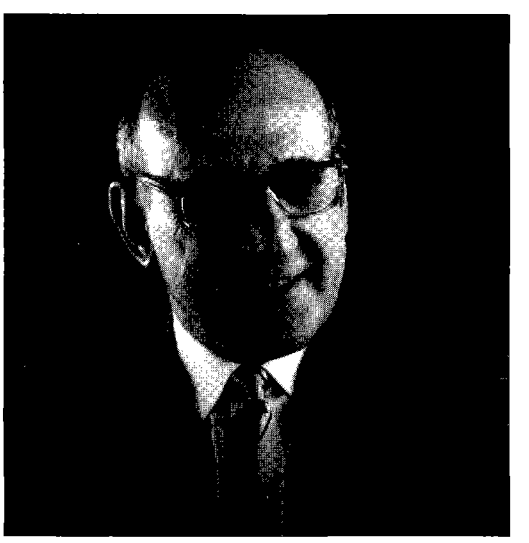

Plate 10.2. Milton P. Siegel (b. 1911), Assistant Director-General of WHO responsible for administrative and financial matters, 1947–1971.

Plate 10.3. Administrative staff at WHO Headquarters who played an especially important part in supporting the smallpox eradication programme. **A:** Adriano M. Imbruglia (b. 1925), Chief, Budget, 1971–1984. **B:** Irwin T. Brooks (b. 1916), Chief, Supply Services, 1968–1977. **C:** Alistair J. S. Taylor (b. 1923), Chief, Administration and Finance, WHO Regional Office for South-East Asia, 1972–1975; then Chief, Personnel, 1975–1983. **D:** John F. Carney (b. 1920), Chief, Finance and Accounts, 1972–1980.

difficult to implement the necessary changes and to persuade regional directors, government officials and donor agencies of the programme's need for support.

The Smallpox Eradication Unit in Geneva

The Smallpox Eradication unit in Geneva consisted throughout most of the programme of only 10 persons—4 medical officers, 1 administrative officer, 1 technical officer and 4 secretaries. Even this number had originally been considered excessive by senior WHO staff, who then envisaged the unit's activities as consisting of little more than ensuring that each country received adequate resources for conducting mass vaccination campaigns (see Chapter 9). During the first year of the Intensified Programme, however, it became apparent that far more than this was required and, indeed, that additional personnel would be useful. However, requests for additional staff were rejected, in part because of pressures by WHO Member States to limit the size of Headquarters staff. But short-term consultants could be recruited, and in 1968–1969, Dr Gordon Meiklejohn served on the staff during a sabbatical year's leave from the University of Colorado; in 1969–1970, Dr Paul Wehrle, on similar leave from the University of Southern California, also worked in the unit. Every year subsequently, each undertook special tasks on behalf of WHO for 4–6 weeks during his university vacation.

Some compensation for the dearth of staff was provided by the fact that many of those in the Headquarters Smallpox Eradication unit served for long periods; this ensured continuity and consequently a greater ability to anticipate the problems of the Organization and of governments in the endemic countries (see Table 10.1).

Late in 1970, an interregional team of 3 additional medical officers was authorized to provide short-term emergency assistance wherever required and to help in establishing surveillance programmes where these were lacking. One was recruited and assigned to Ethiopia, in which that greatly understaffed programme was just beginning, and 2 to West Pakistan when that region was divided into 4 provinces with 4 essentially autonomous smallpox programmes (see Chapter 14). As their presence in these assignments continued to be necessary, they were effectively lost to the Headquarters complement, though remaining chargeable to the Headquarters budget since the Regional Office for the

Table 10.1. Length of service and relevant previous experience of the professional staff of the Smallpox Eradication unit at WHO Headquarters, 1966–1987

Name	Position	Period	Previous experience
Dr D. A. Henderson	Chief Medical Officer	1966–1977	
Dr Isao Arita	Medical Officer	1965–1977	WHO adviser in Liberia, 1963–1965
	Chief Medical Officer	1977–1985	
Dr Zdeněk Ježek	Medical Officer	1980–1985	WHO Smallpox Eradication and Epidemiological Advisory Team, South-East Asia Region, 1972–1977; WHO adviser in Somalia, 1977–1979
	Chief Medical Officer	1985–1987	
Dr Ehsan Shafa	Medical Officer	1971–1977	WHO Regional Adviser on Smallpox Eradication, Eastern Mediterranean Region, 1967–1971
Dr Stephen Falkland	Medical Officer	1966–1969	
Dr Georgij Nikolaevskij	Medical Officer	1967–1971	
Dr Anatolij Slepushkin	Medical Officer	1971–1976	
Dr Joel Breman	Medical Officer	1977–1980	AID adviser in Guinea, 1968–1970
Dr Alexander Gromyko	Medical Officer	1977–1983	WHO short-term consultant in India, 1974
Dr Lev Khodakevich	Medical Officer	1983–1986	WHO adviser in India, 1973–1977, and in Ethiopia, 1978–1979
Mr John Copland	Administrative Officer	1966–1977	
Miss Ija Jurjevskis	Technical Officer	1967–1969	
Mrs Linda Licker	Technical Officer	1969–1970	
Mr John Wickett	Technical Officer	1970–1977	
	Administrative Officer	1977–1979	
	Consultant	1983–1987	
Mr Robert Evans	Technical Officer	1978–1979	AID adviser in Nigeria, 1968–1970
	Administrative Officer	1980	
Mr James Magee	Public Information Officer	1978–1980	

Eastern Mediterranean stated that it had no funds with which to take them over. Other efforts to increase the size of the Headquarters Smallpox Eradication unit were unsuccessful. In consequence, the few professional staff based in Geneva of necessity undertook a wide range of activities both at Headquarters and in the field. As the programme progressed, they had to travel more and more, to the point that most were in travel status for 50–70% of the time.

A partial listing of the activities undertaken by the unit gives some insight into the nature of day-to-day operations. In the interests of the morale of field staff and the acceleration of operations, priority was given to all communications from the field, the aim being to respond to queries or requests within 48 hours of receipt. A surveillance report was prepared for publication every 2–3 weeks in the *Weekly epidemiological record* and more extensive summary reports on the programme twice a year. Voluntary contributions were repeatedly sought through special mailings and visits to governments and other potential donors. Arrangements were made for the testing of vaccine and for its shipment to a central depot in Geneva. Stocks of vaccine, bifurcated needles, jet injectors, kits for the collection and dispatch of specimens and training aids were kept in Geneva and sent on request, to countries. Specimens from patients were received weekly from different countries, repacked and sent to reference laboratories for testing; the results were sent by telex to those submitting the specimens (see box). Each year 1–2 international meetings were arranged for senior smallpox eradication programme staff from regional groups of endemic countries, as well as annual conferences of WHO's regional smallpox advisers, biennial meetings of the research group concerned with monkeypox and related problems, meetings of the WHO Expert Committee and the WHO Scientific Group on Smallpox Eradication, and a special meeting dealing with vaccine production. Various training and educational instruments were prepared—manuals, posters, slide series, teaching exercises and films. An extensive correspondence was conducted on the recruitment of personnel, regional and national budgets and programmes, and the procurement of supplies and equipment. Press releases were prepared and media queries answered. Reports from field staff dealing with their work and observations were edited and published twice a month.

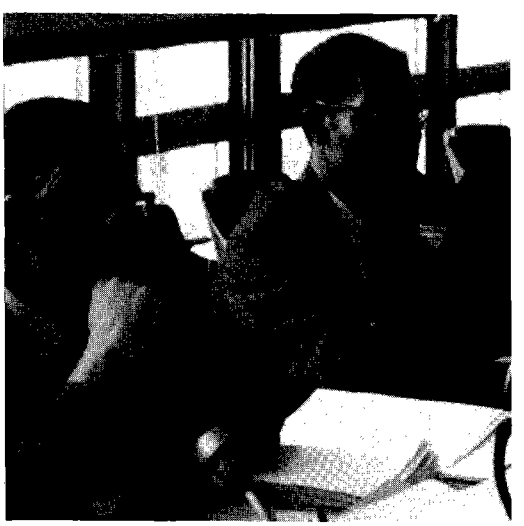

Plate 10.4. Participants in the meeting of the WHO Expert Committee on Smallpox Eradication in November 1971. The chairman (*right*) was Francis C. Grant (b. 1924) of the Ministry of Health of Ghana, who had been a smallpox eradication consultant for WHO in Burma in 1970. The rapporteur was Paul F. Wehrle (b. 1921), a United States professor of paediatrics who had helped to establish the global eradication programme while serving as a WHO consultant in Geneva, 1969–1970.

Because of the heavy travel commitments of the unit's staff, there was insufficient time to perform all these functions well. Had there been adequate manpower, the following 3 activities, in particular, could usefully have received more attention and this, almost certainly, would have reduced the time required to achieve eradication: (1) field studies to define more precisely the status and epidemiology of smallpox in different areas and to evaluate alternative methods of smallpox control; (2) field demonstrations, extending over 2–3 months, of surveillance–containment methods; and (3) personal contacts with potential donors to explain the programme and to seek support.

The Smallpox Eradication unit had comparatively few collaborative relationships with other technical units at WHO. One other unit with which it worked closely was that responsible for implementing the provisions of the International Health Regulations. This unit received weekly telegraphic reports of cases of the quarantinable diseases, including smallpox, and published them in the *Weekly epidemiological record*. These activities are described below, in the section

Plate 10.5. Staff of the Smallpox Eradication unit at WHO Headquarters. **A:** Donald Ainslie Henderson (b. 1928), Chief, 1966–1977. **B:** Isao Arita (b. 1926), Medical Officer, 1965–1976; then Chief, 1977–1985. **C:** John S. Copland (b. 1930), Administrative Officer, 1967–1977. **D:** John F. Wickett (b. 1944), Technical Officer, then Administrative Officer, 1970–1980, and consultant, 1983–1987. **E:** Susan E. Woolnough (b. 1948), secretary to Henderson and Arita, 1970–1985. **F:** Celia I. Sands (b. 1945), secretary, 1969–1981.

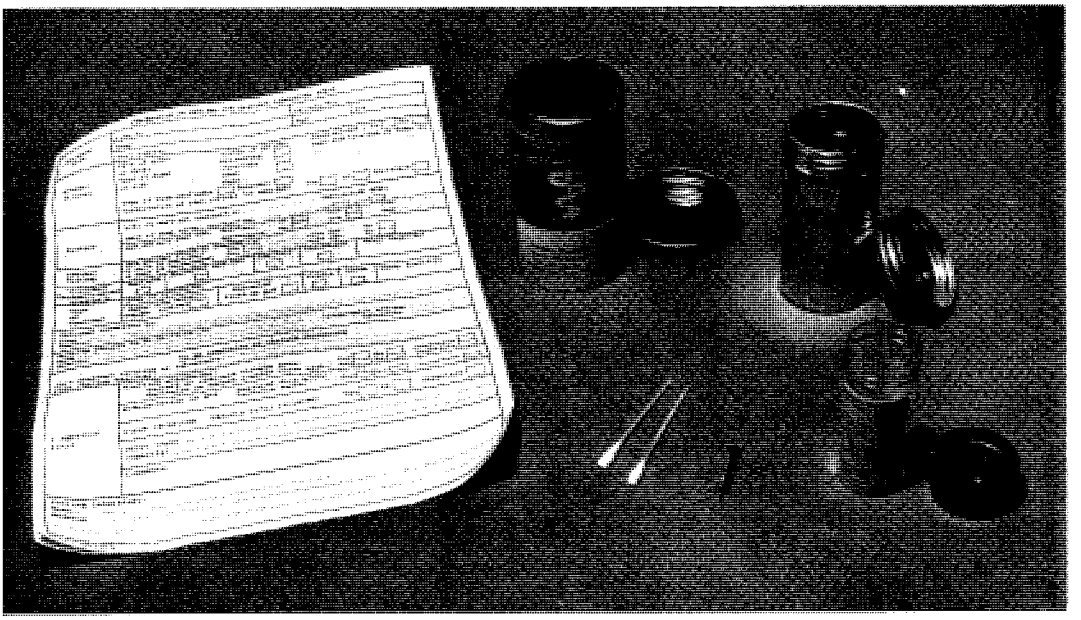

Plate 10.6. Kit provided by WHO for the collection and dispatch of virological specimens.

entitled "Surveillance and notification of smallpox cases". Collaboration with such units as those dealing with health education and maternal and child health would have been logical and potentially productive but most of them were small, with only 2 or 3 professional staff, few of whom were directly concerned with field operations. The only programme of substantial size and with extensive field activities was that for malaria eradication, but by the mid-1960s it had begun to encounter major problems which fully occupied its staff. The only other immunization programme, until 1975, was that for tuberculosis, which was the responsibility of the Tuberculosis unit. However, the staff of that unit were also few in number and much of their time was devoted to field trials aimed at assessing the efficacy of BCG vaccination.

WHO Regional Offices

The WHO regional offices were positioned administratively between WHO Headquarters and countries and were expected to play a major role in the development and coordination of all types of country programmes in their respective regions. For them, the Intensified Smallpox Eradication Programme differed from others for which they were responsible in that it required more or less simultaneous activities in all countries, both to monitor the occurrence of smallpox and to undertake programmes to eradicate the disease or to detect and contain importations. Its needs were different, therefore, from those of tuberculosis control or maternal and child health, for example. Programmes such as these were often country-specific, and it was usually of little moment to the region as a whole or to other countries whether one or more countries did or did not undertake special activities or whether a given disease was widely prevalent elsewhere or not. It might seem that experience acquired in malaria eradication would provide a model, but it did not. National malaria eradication programmes had been implemented with WHO assistance in South America and Asia but in only one country of sub-Saharan Africa (Ethiopia). Most of the smallpox-affected countries that also had endemic malaria had not progressed beyond the "attack phase", in which systematic spraying was the primary activity. Even where there was surveillance it tended to be purely national in character, since knowledge of the malaria status of neighbouring countries was of little interest except in certain border areas.

Most WHO regional offices did not, at that time, initiate health programmes. Rather, they responded to requests for assistance from governments. Owing to budgetary constraints, the travel of regional office staff

Processing of Specimens from Suspected Smallpox Patients

Specimens from suspected smallpox patients from all parts of the world were sent to Geneva and, once a week, sent by air, alternately to the WHO collaborating centres in Atlanta (Center for Disease Control) and Moscow (Moscow Research Institute for Viral Preparations). This practice was followed so as not to overburden either laboratory. Most specimens were received in Geneva in collection kits designed and provided by WHO (see Plate 10.6). The kit included a stylette and swabs for taking specimens, and a screw-capped glass vial into which the specimen was to be placed and which, in turn, fitted into a screw-capped metal container. Two copies of a form providing identifying information about the patient were wrapped around this second container and the contents placed in yet a third screw-capped cardboard shipping container. When received in Geneva, only the outer container was opened, one copy of the form removed and the specimen logged in. Laboratory results were sent to Geneva from the laboratory by telex or telephone and relayed, in turn, to the responsible health administration.

Although no problems arose with this method of handling specimens in Geneva, it is seen, in retrospect, to have been less than satisfactory, since it assumed that neither the form nor the second container was contaminated with variola virus and thus capable of causing infection. However, health officials in some countries sent specimens in other types of containers, including envelopes and small boxes, which were sometimes only partially sealed. Miss Sands, who dealt with the specimens, was revaccinated every year, as were all the staff, but she opened and processed the specimens at an ordinary secretary's desk in an open room.

While unthinkable now, the system, at the time, appeared to provide reasonable safeguards against the chance infection of others in Geneva. The infection of personnel handling specimens, even in laboratories, was uncommon and, until the mid-1970s, laboratory precautions consisted in little more than the vaccination of personnel. The occurrence of smallpox in 1978 in Birmingham, England, in a person exposed to virus carried by an air duct from one room in a laboratory to another demonstrated the need for more stringent precautions.

Another concern present throughout the course of the programme was that of the possible loss of specimens in shipment. Thanks to a rigorous, continuing check of bills of lading against receipt of shipments, this did not occur, but, as a precaution, specimens sent from Geneva to Moscow and Atlanta were packed in large containers which would be less likely to be mislaid.

tended to be restricted. Efforts to persuade WHO regional directors that the needs of global smallpox eradication called for a somewhat different approach met with only limited success, varying from region to region. The Region of the Americas and the Eastern Mediterranean Region immediately appointed full-time advisers on smallpox eradication, and a year afterwards two medical officers in the South-East Asia Region were given full-time responsibility for smallpox eradication. In these regions, programme planning, the recruitment of staff and the procurement of supplies and equipment were most efficiently conducted. In the African Region, however, until certification activities began, responsibilities for the smallpox eradication programme were assigned as a part-time responsibility to the adviser on tuberculosis or on all communicable diseases. Not only did this region include more countries than any other, with some of the world's least developed health systems but, in addition, communications between the regional office and countries were poor and travel was difficult. As is described in the chapters dealing with field operations, there were continuing problems of every type in endeavouring to develop and support national programmes. In all regions, however, a lack of personnel in the regional offices and the customary constraints on their travel handicapped programme development. Where only a single adviser was involved, his absence on leave or duty travel meant that communications often went unheeded and

other activities, such as recruitment and the procurement of supplies and equipment, slowed down or ceased altogether. As a result, Headquarters staff travelled far more frequently and extensively than might otherwise have been necessary for a programme having a regional structure.

The regional offices were at that time likewise largely unaccustomed to the coordination of plans, needs and resources within a global context. To try to achieve better coordination, the Headquarters Smallpox Eradication unit held annual meetings for those responsible for smallpox eradication in each region to discuss goals, plans and progress. At the meetings, priorities were decided and needs identified, including funds, vaccine, vaccination instruments, personnel, and training aids. Such meetings were usually held in conjunction with a WHO-organized multinational meeting of programme staff, at which strategy and recent field observations were also discussed. Whatever the venue, it was always necessary to make a special appeal to one or several of the regional directors to obtain permission for advisers to attend, a permission which was usually but not always granted and then only on the condition that Headquarters funds would be used for travel. Although the meetings proved invaluable, it was never possible to achieve a rational allocation of funds, as will be discussed later.

WHO Representatives in Countries

The WHO representatives in countries provided the point of contact between WHO and the countries; they were assigned to most developing countries to assist in formulating policy and developing projects, and to provide administrative and technical guidance to WHO-supported programmes. Some of them had had many years of experience in international health work, but most were recent recruits who had held senior positions in their own national health services. They took up their positions after a short briefing, largely of an administrative character, and usually met their regional directors and other WHO representatives once or twice a year. Few were experienced or knowledgeable in smallpox eradication and, because of their

Plate 10.7. **A:** Nicole Christiane Grasset (b. 1927) served as adviser for smallpox eradication in the South-East Asia Region of WHO, 1970–1976, succeeding Jacobus Keja who had been an adviser there from 1967. **B:** Ahmad J. Hajian (b. 1920) was the smallpox eradication adviser in the Eastern Mediterranean Region of WHO, 1971–1977, replacing Ehsan Shafa (Plate 10.12).

numerous other responsibilities, few could make any substantial contribution specifically to the Intensified Programme.

Smallpox Eradication Programme Staff

The quality and commitment of international staff proved to be one of the most important factors in the successful eradication of smallpox, and considerable time and effort were expended by the Smallpox Eradication unit on recruiting them. The task was not an easy one, however. Epidemiologists with experience in infectious disease control were particularly desirable because of the need to initiate and foster epidemiological surveillance. In 1967, however, few were available, and of those who were, almost none had ever seen cases of smallpox. Most were recruited on the strength of their experience in the management of health programmes, special consideration being given to basic competence and motivation. Specialized training in smallpox eradication methods would have equipped them better for their assignments but many difficulties were encountered in providing it. Thus, adequate numbers of fully qualified staff did not become available until the Intensified Programme was well advanced.

The provision of special training programmes in smallpox eradication proved impracticable, except for international and senior national staff working in the programme conducted with United States assistance in western and central Africa. For these, from 1966 onwards, the Communicable Disease Center (which has been renamed on several occasions and is now the Centers for Disease Control and widely known simply as CDC) provided a 4-week training course every year. Only a few WHO staff attended because WHO regional offices were unaccustomed to providing specialized training for newly recruited staff, as most were already experienced in the work that they were expected to do. In any event, by 1970, because of the early interruption of smallpox transmission in western and central Africa (see Chapter 17), the CDC course had so changed in character as to be of limited value for those engaged in the early phases of an eradication programme. WHO had provided specialized training at malaria eradication centres, but smallpox eradication was widely perceived as consisting in little more than mass vaccination, for which little specialized knowledge was thought to be needed. A WHO-conducted interregional training course was not available as an option because most regional offices did not wish to incur the expense of sending new advisers to Geneva for briefing, Most new staff therefore took up their positions with a briefing of a week or less in their respective regional offices, provided that there was a smallpox adviser in the region to brief them and that he was not then on duty travel. Not until 1974, when the number of international staff increased substantially, did WHO begin to provide organized training programmes for its staff. These were conducted at national level, first in India and then in Bangladesh and Somalia, concurrently with their large-scale intensified programmes.

Other methods were used to educate and orientate newly recruited staff. It was believed and subsequently confirmed that the clinical characteristics of smallpox could soon be learned after arrival in the country. For this purpose, the following were available: the WHO Handbook; a 4-colour, 8-page printed folder showing pictures of smallpox in African patients and describing the course of the disease (1969); sets of teaching slides showing smallpox in African patients (1969) and Asian patients (1971); and a large wall chart showing the appearance of smallpox and chickenpox rashes at various days after the onset of the disease (1970).

The epidemiological principles underlying proper surveillance and containment proved more difficult to convey. Many different approaches were used, beginning with the instructions provided in the WHO Handbook. Later, two case histories with syllabuses were developed, one dealing with techniques for the investigation and control of an outbreak (SE/71.1) and the other with surveillance–containment measures to be taken in an area with a population of about 2–3 million (SE/72.7). (The latter was adapted for use as a case history by the Harvard School of Business Administration.) On-site tutorial training was provided by WHO Headquarters and some regional smallpox eradication programme staff, and periodic intercountry meetings were structured to emphasize surveillance–containment methods and to illustrate approaches. Reports and materials distributed every 2–3 weeks in the so-called "biweekly mailing" (see below) also proved useful. All these efforts, however, fell short of what was required, as was shown by

the length of time required to implement surveillance–containment programmes in most areas and the fact that some African countries were never fully successful in doing so.

Difficulties in communicating with staff working in the field also hampered efforts to develop expertise and solve problems. All communications from Headquarters had to be routed through the appropriate regional office, logically the principal point of contact for the countries in that region. Where there was a full-time smallpox adviser and the region comprised few countries—South-East Asia, for example—reasonably close contact with field staff and programmes in the countries was possible. Where there was no full-time adviser and the countries in the region were numerous, as in Africa, communications were difficult and special measures were necessary. The nature of the problems may be illustrated by the fact that, if a letter was sent from Geneva to the regional office inquiring about the status and needs of a national programme, it was usually necessary for a regional adviser to prepare a special letter for the signature of one of his superiors or the regional director. After drafting and revision, the letter would then be sent to the WHO representative, who would contact either the WHO smallpox adviser or the national health authority. When the information had been obtained, a letter of reply would be prepared and the procedure repeated in reverse. Since the mail was slow and unreliable almost everywhere, it was exceptional to receive a reply to a query from Geneva in less than several months, if it was received at all.

This problem was overcome to some extent by arranging for copies of important correspondence and telex messages to be sent direct from a country to Geneva, and for Headquarters staff, likewise, to send a copy of the reply to the country, the original being sent to the regional office as prescribed. This was of crucial importance in many instances, for example, in dealing within days with an acute shortage of vaccine in Uganda at a time when a telex message "through the proper channels" took 8–9 weeks. Although this approach violated the prescribed procedures, field staff frequently noted that the immediate responsiveness of Headquarters staff to their requests and queries played an important role in sustaining morale and giving impetus to the programme.

Up to the end of 1967, WHO smallpox eradication programme staff throughout the world numbered less than 30. Additional WHO staff were required as national programmes began but recruitment proceeded slowly, the ability and dedication of recruits varying greatly. Except for those who were assigned to Geneva or were members of an interregional team, recruitment and selection were the responsibility of the regional offices, whose personnel services operated independently of Headquarters. Headquarters smallpox eradication staff endeavoured to assist the regional offices in identifying suitable candidates through personal contacts and the screening of applications received in Geneva, but proposals at first were as often ignored as accepted. An especially discouraging episode was the assignment by one regional office of a particularly well qualified candidate to an entirely different programme after months of work by Headquarters smallpox eradication staff to recruit him to WHO for work on smallpox eradication.

Because of the problems, such impetus as the programme possessed during its first few years was provided by a very small number of qualified WHO staff, the staff of the programme conducted with United States assistance in western and central Africa, and national staff. Among the WHO staff were Dr Pierre Ziegler, who worked in Zaire; Dr Celal Algan in Rwanda; Dr Karel Markvart in East Pakistan; Mr Henry Smith in Kenya; Mr Leo Morris in Brazil; Dr Jacobus Keja in the Regional Office for South-East Asia; and Dr Ehsan Shafa in the Regional Office for the Eastern Mediterranean. Eventually, however, a reasonably satisfactory collaborative relationship with respect to recruitment evolved between Headquarters and two of the four Regions concerned.

At first, many international staff were transferred from other projects which were not progressing well or in which the staff had proved unsuitable. Over a number of years, some of the less effective and less industrious staff were transferred by WHO to yet other programmes or did not have their contracts extended. A stated policy of the programme that all smallpox eradication staff should spend at least one-third of their time in the field facilitated this weeding-out process, the policy being monitored, where necessary, by review of daily tour diaries.

Especially helpful in the recruitment of more capable staff were senior epidemiolo-

Plate 10.8. **A:** A pictorial guide to the diagnosis of smallpox in African patients, published by WHO in 1969, which included pictures of patients with chickenpox for comparison. **B** and **C:** WHO issued posters with ample white space in which messages could be overprinted in local languages. The patient in **B** was photographed in Zaire, in **C** in Pakistan. The reward poster, **C,** overprinted in Indonesia, says: "5000 rupiahs to the first person who discovers a real case of smallpox. Please report to the head of the community or the local health inspector and ask about the terms."

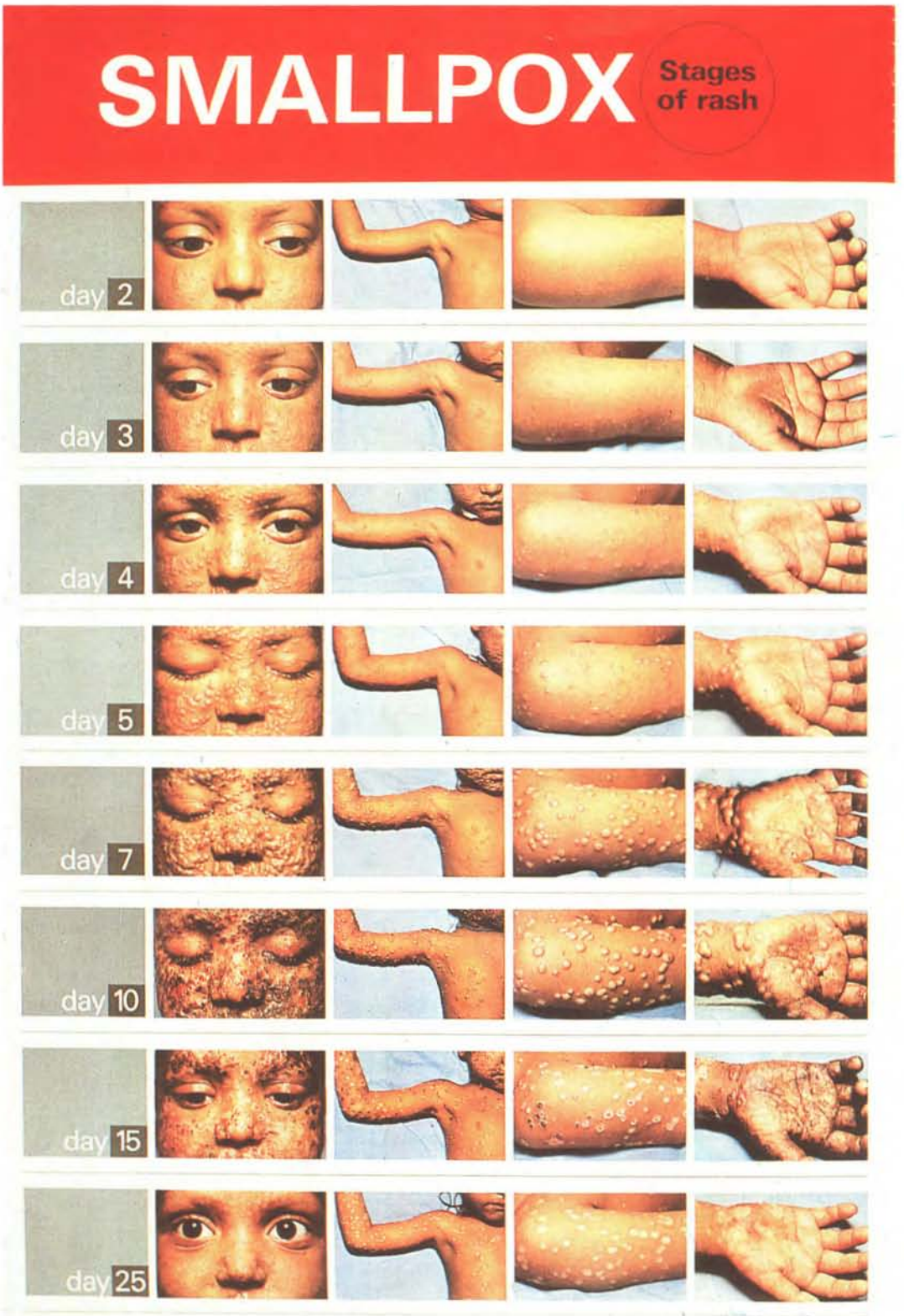

Plate 10.9. The left-hand portion of a large wall poster that contrasted the rashes of smallpox and of chickenpox on 4 areas of the body. English, French and Portuguese versions of this poster were prepared in 1970.

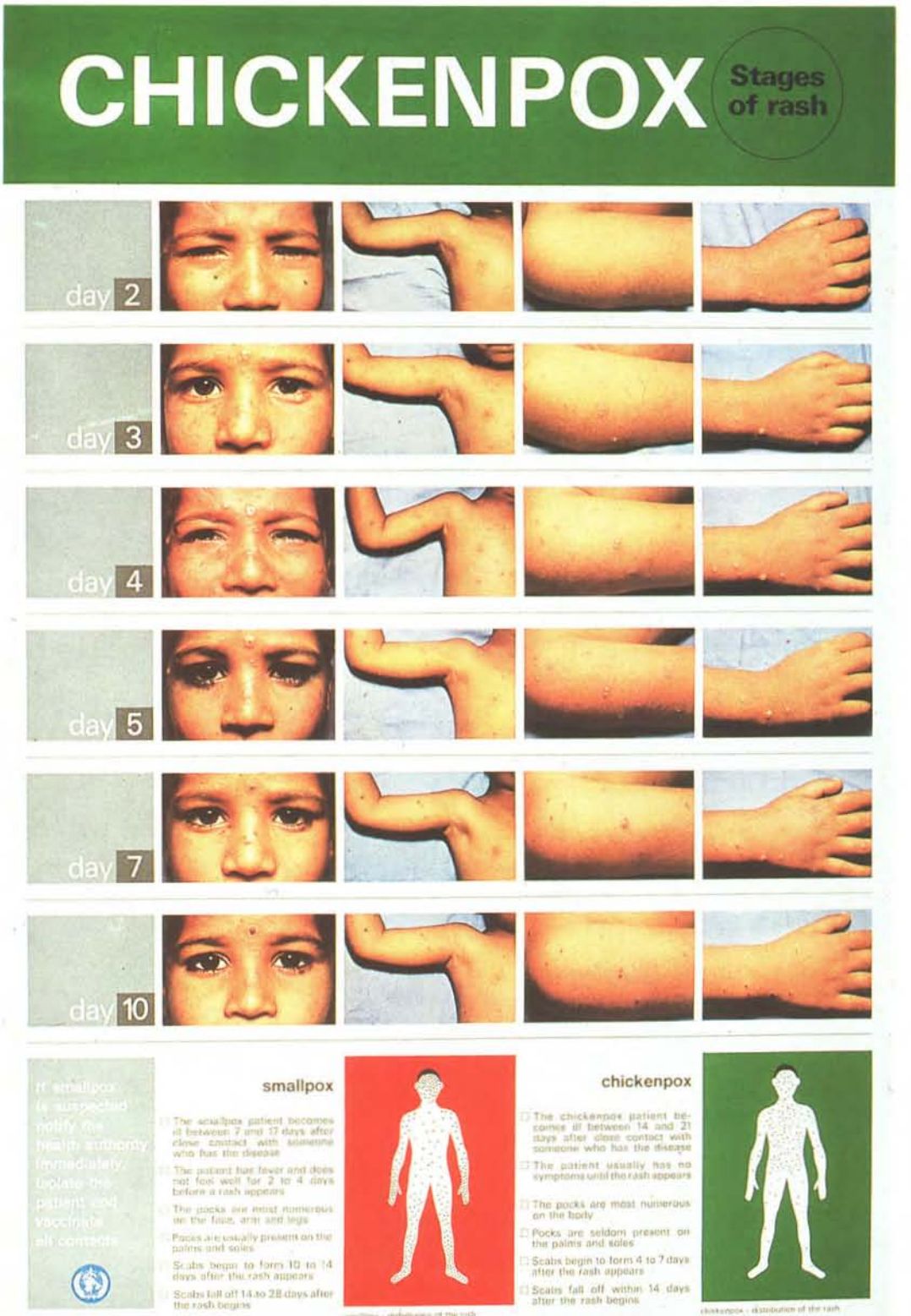

Plate 10.10. The right-hand portion of the poster in Plate 10.9. The text and drawings at the bottom gave simple indications by which to distinguish the signs and symptoms of smallpox from those of chickenpox.

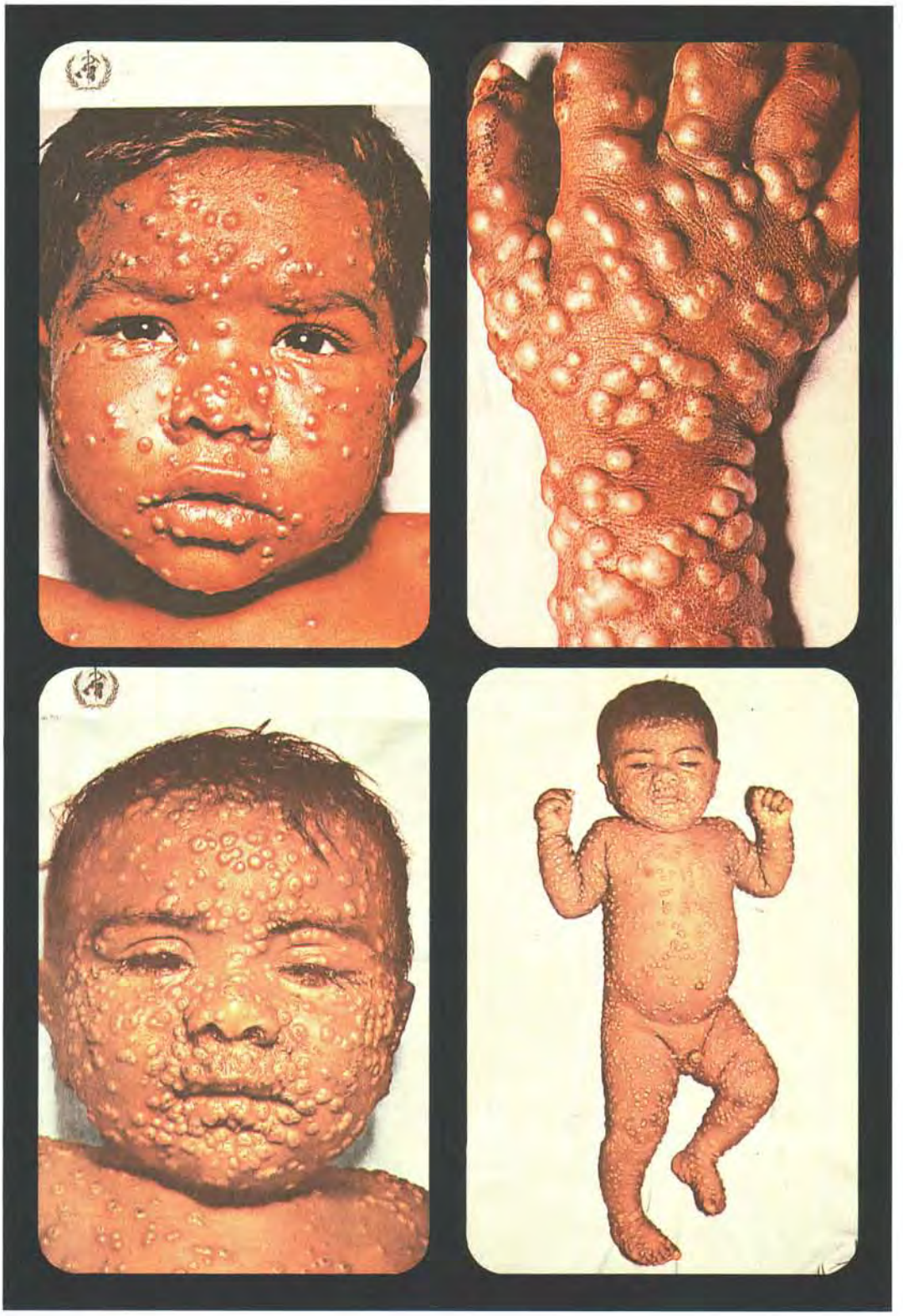

Plate 10.11. The front and back of two versions of the shirt-pocket-size WHO smallpox recognition card produced in 1972. They were first used in India, and tens of thousands were eventually distributed to search workers throughout the subcontinent. The first version (upper pictures) was selected to portray a patient with relatively mild smallpox; it is a reduced version of the larger card shown in Plates 10.29 and 10.30.

Plate 10.12. **A:** Zdeněk Ježek (b. 1932) was attached to the WHO Regional Office for South-East Asia in 1972, working for smallpox eradication in India. He later served in Somalia, before joining the Smallpox Eradication unit at WHO Headquarters in 1980 and succeeding Arita as Chief of the unit in 1985. **B:** Ehsan Shafa (b. 1927) was the smallpox eradication adviser in the Eastern Mediterranean Region of WHO, 1967–1971, and then served with the Smallpox Eradication unit at WHO Headquarters until 1977.

gists from a number of countries who were interested in the programme and aware of its demands and who screened and referred former students and colleagues. Such epidemiologists included Dr Karel Raška, Czechoslovakia; Dr Jan Kostrzewski, Poland; Dr Holger Lundbeck, Sweden; Dr Viktor Zhdanov, USSR; and Dr Paul Wehrle, USA. From early in 1972, when smallpox epidemics unexpectedly occurred in Bangladesh, until 1977, Dr David Sencer, then Director of CDC, made available the services of 5 full-time CDC staff, and from 1974, the High Institute of Public Health in Alexandria, Egypt, provided a number of faculty members and former students.

As the programme progressed, the number of capable staff with field experience gradually increased, and those who had successfully worked in their own national programmes were recruited for service in other countries. These included staff from Afghanistan, Bangladesh, Brazil, India, Indonesia, Nepal, Pakistan, the Sudan, Togo and Yemen.

International volunteers contributed significantly, both while serving as such and subsequently when recruited as consultants or staff. Arranging such volunteer support was difficult, however, because WHO policy until the mid-1970s was that volunteer assistance had to be arranged strictly between recipient and donor governments, WHO staff not being allowed to assist in the process. Unofficial contacts and private correspondence, however, served to facilitate the assignment of United States Peace Corps volunteers in Afghanistan, Ethiopia and Zaire; volunteers from Japan and Austria, who served in Ethiopia; and British volunteers from OXFAM (a British private charitable organization), who worked in India and Bangladesh. Regrettably, an offer by Sweden, in 1970, to assign young medical officers at Swedish government expense to WHO itself had to be rejected by the Organization for policy reasons.

Until 1973, international staff assigned to a country rarely numbered more than 1–4, with the exception of large countries and those with an especially difficult terrain and a shortage of national personnel—Afghanistan, Bangladesh (from 1972), Ethiopia, Nigeria and Zaire. From 1973 onwards, increasingly large numbers of international staff worked in Bangladesh and India and later in Ethiopia and Somalia as more funds became available and efforts were intensified to achieve eradication in the shortest possible time. Throughout the course of the global programme, however, international staff of all types at any given time never numbered more than 150. In all, 687 WHO staff and consultants from 73 different countries eventually served in the programme for periods

ranging from 3 months to more than 10 years; approximately 125 others served with the programme under bilateral agreements. Most of the staff were less than 40 years of age and some less than 30, youth being an advantage where living and travelling conditions were difficult.

Although international staff were few, they played an important role in sustaining national government support, providing programme continuity where national leadership changed for political or other reasons, and expediting the transfer of new techniques from one programme to another. In retrospect, it may be said that few national programmes achieved much success where international staff were of poor quality, but national staff, given the necessary support and encouragement, showed themselves to possess a skill and dedication which equalled and often exceeded those of the international advisers.

OBTAINING NATIONAL AGREEMENTS TO UNDERTAKE PROGRAMMES

Although commitments assumed by governments by virtue of votes in favour of resolutions at the World Health Assembly were morally binding, WHO could not force governments to undertake programmes. Thus, although the Intensified Smallpox Eradication Programme was unanimously approved by the Health Assembly, only certain countries were, in fact, then prepared to undertake eradication programmes—much as had been the case during the period 1959–1966. Some lacked resources, while others considered that other health problems were of higher priority. Universal participation was essential if the programme was to succeed but, as described earlier, WHO's role in actively promoting and advocating a particular programme in all countries was an unaccustomed one. Malaria eradication was the only other programme in which this had been attempted but, in that programme, the necessary but substantial additional national costs had distorted health allocations, and the extent to which its secondary objective, the improvement of basic health services, had been attained had fallen far short of expectations. Mindful of this experience and doubtful of the feasibility of smallpox eradication, the Director-General cautioned his regional directors, at a meeting immediately after the 1966 World Health Assembly, against appearing to impose a smallpox eradication programme on any country. Thus, in 2 regions, Africa and South-East Asia (unfortunately also those most seriously affected by smallpox), the regional directors did not initially promote smallpox eradication programmes, assistance being provided only to countries specifically requesting it. In the Region of the Americas and the Eastern Mediterranean Region, however, eradication programmes were actively promoted from the beginning.

In the Americas, smallpox eradication was not a new objective, a regional eradication programme having been in existence since 1950 (see Chapter 9). A Regional Adviser on Smallpox Eradication, Dr Bichat Rodrigues, was appointed in 1966 to coordinate the effort, and Brazil, the only endemic country, committed itself to a national smallpox eradication programme employing what were then the new jet injectors (see Chapter 12). Vaccination campaigns in many other countries in South America began soon thereafter. In the Eastern Mediterranean Region, there were then 3 endemic countries—Ethiopia, Pakistan and Yemen—and there, also, an adviser on smallpox eradication, Dr Shafa, was immediately appointed. He successfully promoted programmes in Pakistan, Yemen and other countries of the region although, for reasons beyond his control, he was unsuccessful in Ethiopia, in which a programme did not begin until 1971 (see Chapter 21).

In the South-East Asia Region, the Regional Director shared the Director-General's belief that eradication represented an unattainable goal, given the stage of development of national health services (see Chapter 9). Responsibility for smallpox eradication was assigned to a 2-man intercountry advisory team which dealt with other communicable diseases as well and whose budget for travel was small. Little was done in the Region until Dr Herat Gunaratne was elected Regional Director in 1968; coming from Sri Lanka, a country which had eliminated endemic smallpox decades before, he saw no reason why this could not be achieved elsewhere. He therefore made the intercountry team, Dr Keja and Dr Louis Gremliza, responsible solely for smallpox eradication and, from the time of his election, played

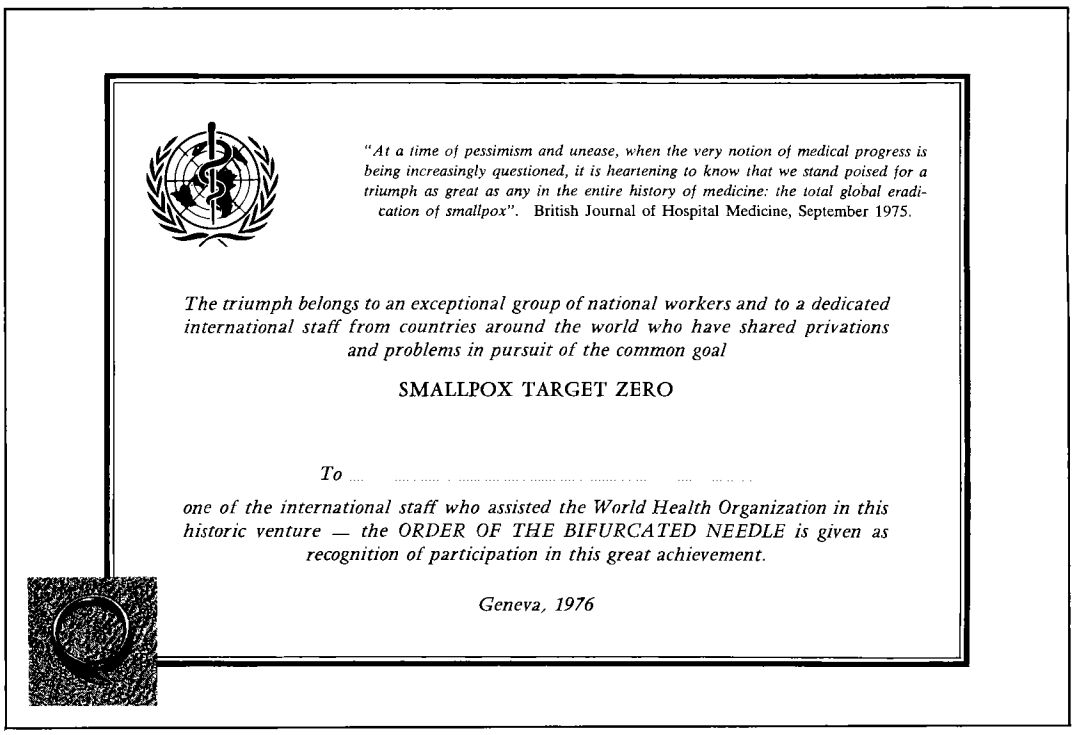

Plate 10.13. The contribution of the international staff who participated in the eradication of smallpox was given sincere if informal recognition by their promotion to the mock "Order of the Bifurcated Needle", accompanied by an official-looking certificate and a hand-made lapel pin. The pins (*inset*) were fashioned from bifurcated needles in the form of an "O" to symbolize "Target Zero", the objective of the programme.

an active role in encouraging national programmes. The response was generally enthusiastic and within a year effective programmes were in progress in all endemic countries of the region except India, where the programme started later (see Chapter 15).

In the African Region, by late 1966, a number of countries had already committed themselves to national smallpox eradication programmes. These included the 20 countries of western and central Africa which were participating in the smallpox eradication and measles control programme being carried out with the assistance of the USA; Zambia, which had begun a national vaccination campaign in 1966 because of epidemic smallpox; and Zaire, whose WHO-supported activities were then coordinated by Geneva Headquarters. The other African countries did not officially express any interest in 1966 and early in 1967. This was disturbing to the staff in Geneva, but also puzzling because funds were then available to meet all the costs of the programmes except salaries for the comparatively small number of national personnel who would be required. Because WHO was prepared to provide vaccine free of charge and because many countries already employed smallpox vaccinators, it was actually cheaper for most of them to participate in the eradication programme than to continue smallpox control activities. They failed to express interest, as was later discovered, because no effort was made by the Regional Office to encourage programmes, acquaint national authorities with the programme's budgetary implications, or indicate the amount of support which could be provided by WHO; instead, the national authorities were expected to request WHO's assistance on their own initiative. The WHO representatives in the countries, as well as Ladnyi, then intercountry smallpox adviser for East Africa, were informed of this policy in September 1966. In the spring of 1967, the problem was resolved fortuitously when a member of the Headquarters Smallpox Eradication unit was given permission to visit several of the countries for the purpose of gathering information for the Director-General's report to the 1967 World Health Assembly. Although he was forbidden to

suggest to any country that a programme should be undertaken, he made the health authorities aware of the nature of the programme and the resources available and, within weeks, letters requesting WHO assistance were received from almost all of them.

By the summer of 1969, smallpox eradication programmes had begun in all the endemic countries in Africa except South Africa, Southern Rhodesia (now Zimbabwe) and Ethiopia. WHO then had no official relations with the first two of these, South Africa having ceased to participate in the Organization and Southern Rhodesia being technically still a colony of the United Kingdom, although it had unilaterally declared independence. Visits by WHO staff were not permitted and little information could be obtained about the status of smallpox or their programmes. However, neither was thought to represent a serious impediment to eventual global eradication because neither officially reported many smallpox cases and their health services were comparatively well developed. Both began special programmes in 1970 (see Chapter 20), stimulated largely by reports in the *Weekly epidemiological record*, which described excellent progress in smallpox eradication elsewhere in Africa but noted the lack of information from South Africa and Southern Rhodesia. The third country, Ethiopia, although in Africa, was served (until late in 1977) by the Regional Office for the Eastern Mediterranean and presented quite a different problem. Smallpox was widely endemic and health services were few, but malaria eradication staff and their international advisers, fearing that another programme would be a harmful distraction, persuaded government officials to refuse to discuss with WHO the implications of a smallpox eradication project. Not until late in 1969 did the government permit Henderson and Dr Shafa to visit the country. At that time, Ministry of Health officials declined to participate but the Emperor himself, who by chance had heard about the programme, intervened to commit the government and, in 1971, the last of the programmes in the endemic countries began (see Chapter 21).

Thus, although many countries needed to be encouraged and persuaded to undertake smallpox eradication programmes, these had, in fact, been initiated in all endemic countries within 5 years of the 1966 decision. It was quite another problem to ensure that the various governments were sufficiently committed for eradication of the disease to be achieved.

SUSTAINING GOVERNMENT INTEREST AND COMMITMENT

A continued high level of interest and support for the eradication programme was difficult to sustain in many countries, just as it was in WHO. Changes in governments and/or senior health personnel were often associated with differences in priorities and in levels of commitment. Smallpox was but one of many problems competing for attention and resources and, in countries in which the mild variola minor form was prevalent, it was understandably not of high priority. After the last known cases had occurred, resources were particularly difficult to obtain from recently endemic and donor countries, as well as from WHO itself, in order to continue surveillance and thus permit certification.

Role of the World Health Assembly

The World Health Assembly, convened each year for a period of several weeks, was a particularly important opportunity for promoting and sustaining interest in the smallpox eradication programme. Senior health officials from all Member States attended and, in addition to reviewing the proposed WHO budget, discussed the Organization's overall programme of work as well as specific programmes, such as that for smallpox eradication. During the debate, delegates frequently described what their own countries were doing, some asked questions of a technical nature and others took the opportunity to announce voluntary contributions. The Intensified Smallpox Eradication Programme, if included as an agenda item, might be discussed for 2–4 hours or more. Such a discussion served to focus the attention of health officials on the subject, and important principles—such as the role of surveillance and the need to use only freeze-dried vaccine—could be emphasized by the Secretariat. It also enabled government officials to hear what were often heartening or optimistic reports of progress in other countries, causing them to reexamine their own programmes. If, however, smallpox eradication was not included in the agenda as an item for

debate, it could still be discussed when the overall programme of the Organization was considered, but it was unusual for many delegates to prepare themselves to speak on the topic and the debate was usually brief.

Because the Health Assembly had identified smallpox eradication as a priority programme of the Organization and it had been on the agenda each year from 1959 to 1967, the Smallpox Eradication unit staff assumed that the topic would continue to be an annual subject for debate on which the Director-General would provide a special report to the Health Assembly. From 1968 onwards, however, it began to be omitted from the provisional agenda. The resolution on smallpox eradication adopted by the Twentieth World Health Assembly (1967), called only for the Director-General "to report further" on smallpox eradication to the Executive Board and the Health Assembly. "Further" was interpreted to mean at some time in the future and the topic was omitted from the provisional agenda of the Twenty-first World Health Assembly (1968), an action which was reversed at the request of the USSR. Resolutions adopted at the 1969, 1971, 1972, 1976 and 1977 Health Assemblies called specifically for special reports to each of the subsequent ones and for smallpox eradication to be included in their agendas. In the other years until 1977, when transmission was interrupted, smallpox eradication was the subject only of a brief general discussion in the context of the overall WHO programme. A report by the Director-General was nevertheless prepared and kept in readiness in case one was requested by delegates. To it was attached a comprehensive review of the programme's progress and status that was published twice a year in the *Weekly epidemiological record* to coincide with the January session of the Executive Board and with the Health Assembly. Although the report was not to be distributed unless requested by delegates, the interest expressed, particularly by two delegates, one from the USSR and the other from the USA (Dr Dmitrij Venediktov and Dr Paul Ehrlich, Jr, respectively), ensured that it was distributed and the programme discussed.

Surveillance Reports

Regularly published surveillance reports, both international and national, were an essential component of the surveillance process and, as experience had demonstrated in other disease control programmes, were also important in stimulating and sustaining the interest of those concerned with the programme. Such reports documented the numbers of cases reported weekly by administrative area, charted trends in incidence and in the progress of the programme, and discussed alternative strategies and tactics in

Plate 10.14. Two delegates to the World Health Assembly and members of the Executive Board of WHO who were strong advocates of smallpox eradication. **A:** S. Paul Ehrlich Jr (b. 1932), Surgeon General of the United States Public Health Service. **B:** Dimitrij D. Venediktov (b. 1929), Deputy Minister of Health of the USSR.

different areas. The first WHO surveillance reports on smallpox eradication were issued in September and December 1967, and from May 1968 onwards, they began to be published every 2–3 weeks in the *Weekly epidemiological record*, some 5000 copies being distributed to health officials and others throughout the world. The system was not established without difficulty, however, as is discussed later in this chapter in the section entitled "International surveillance reports". The WHO Regional Office for South-East Asia also issued surveillance reports from 1974 onwards, and national surveillance reports were published monthly and sometimes weekly or every 2 weeks in a number of countries.

In addition to providing information to widely scattered health staff, the reports also served to inform both public officials and the press, sometimes with unexpected consequences. When, in Brazil, Ethiopia and India, for example, better surveillance and improved reporting were accompanied by marked increases in the numbers of notified cases, national officials and the press expressed concern, and even alarm, although the increases were attributed, at least in part, to better reporting. Greater political commitment and increased resources soon followed. In other countries, interest in the programme grew significantly when national officials read of more satisfactory progress being made in other countries, some of which they believed to have health services inferior to their own.

Interregional and Intercountry Meetings of Smallpox Eradication Staff

Meetings of senior staff from different national programmes also served to sustain and stimulate the interest of governments and staff while bringing to their notice the new observations which were being made. The WHO Headquarters budget provided for at least one such meeting a year, the venue changing from year to year, as did the participants (Table 10.2). In addition, over the period 1967–1972, CDC supported a yearly conference for the countries of western and central Africa.

The first of these meetings was held in Thailand in 1967 for countries in eastern Asia. At first they were largely devoted to the presentation of reports on national programmes by the respective national directors; over time, their nature gradually changed and each country was asked to present papers illustrating specific findings, the outcome of particular strategies and interesting new approaches. The ensuing discussions made it possible to determine whether the observations made in a particular national smallpox eradication programme were of relevance to the others. Most of these reports were distributed by WHO to all concerned with smallpox eradication through the special WHO/SE, SE and SME series of mimeographed documents (see References: WHO documents); some were also published in the medical literature.

Table 10.2. WHO seminars and meetings on smallpox eradication, 1967–1978 (excluding those associated with certification of eradication)

Date	Country in which held	Participants[a]
December 1967	Thailand	13 countries of South-East Asia, Eastern Mediterranean and Western Pacific Regions
November 1968	Zaire	11 countries of southern and eastern Africa
May 1969	Nigeria	18 countries of western and central Africa (joint seminar with CDC)
November 1969	Pakistan	11 countries of Eastern Mediterranean and South-East Asia Regions
December 1970	India	11 countries of South-East Asia, Eastern Mediterranean and African Regions
September 1972	Ethiopia	4 countries of eastern Africa
November 1972	India	5 countries of South-East Asia Region
November 1972	Pakistan	4 countries of Eastern Mediterranean Region
September 1973	Ethiopia	Ethiopia and WHO Eastern Mediterranean Region smallpox eradication advisers
November 1973	Pakistan	Pakistan and WHO Eastern Mediterranean Region smallpox eradication advisers
August 1974	India	Bangladesh, India and Nepal
January 1976	Nepal	6 countries of South-East Asia Region
March 1977	Kenya	4 countries of eastern Africa
September 1977	Kenya	5 countries of eastern Africa
April 1978	Kenya	5 countries of eastern Africa and the Eastern Mediterranean Region

[a] Participants included national programme staff and WHO smallpox advisers and other smallpox eradication staff from the regional offices and WHO Headquarters. Advisers from the regional offices in the 4 endemic regions were invited to all meetings from 1967 to 1970 and to the 1972 meeting in India.

Plate 10.15. Participants in the first interregional seminar on smallpox eradication held in Bangkok, Thailand, 11–16 December 1967. *Left to right, front row*: A. M. Khan (Pakistan), A. R. Rao (India), M. K. Singh (India), S. A. Mallick (Pakistan), D. A. Henderson (WHO), E. Na Bangxang (Thailand), S. Falkland (WHO), J. J. Dizon (Philippines), I. F. Setiady (Indonesia), U Thaung (Burma); *middle row*: Z. Rahman (Pakistan), C. Rubinstein (WHO), C. H. James (United Kingdom), J. Singh (Malaysia), K. S. Ramakrishnan (India), G. P. Nikolaevskij (WHO), W. H. Foege (USA), J. Keja (WHO), B. Ignjatovic (WHO), F. G. L. Gremliza (WHO), B. Wirjodipoero (Indonesia), J. C. Pitkin (WHO), Khin Mu Aye (WHO), K. Chatiyanonda (Thailand), S. Somachai (Thailand); *back row*: C. Patanacharoen (Thailand), A. Prajapati (Nepal), J. S. Copland (WHO), T. M. Mack (USA), G. H. Waheed (Afghanistan), B. Chantasut (Thailand), E. Shafa (WHO), R. M. Lyonnet (WHO), Y. K. Subrahmanyam (India), S. Singh (WHO), P. Tuchinda (Thailand), T. Phetsiriseng (Lao People's Democratic Republic), N. D. Tiep (Viet Nam), P. Kunasol (Thailand), C. Debyasuvarn (Thailand).

The meetings had both tangible and intangible benefits. Several specific changes in programmes can be associated with them: Indonesia's full commitment to smallpox eradication followed the 1967 meeting in Thailand; agreements to grant national surveillance and vaccination teams free passage across specified international borders, a hitherto unprecedented occurrence, followed the 1968 conference sponsored by CDC in Côte d'Ivoire and the 1973 meeting in Ethiopia; and India's decision to adopt the surveillance–containment strategy and to undertake an intensified programme followed the 1972 meeting in New Delhi.

Use of the Mass Media

The Smallpox Eradication unit staff actively sought publicity for the programme in national and international media, believing that it was important to make what was happening in the programme widely known to potential donors and to those in the endemic countries. For many sectors of government, this was a natural and logical approach but there was then, both in WHO and in many countries, a reluctance on the part of physicians and other health personnel to meet representatives of the mass media or to use the media except to convey traditional health education messages. The very small staff and limited programme of WHO's Division of Public Information at that time was a reflection of this attitude.

The publication of the semi-annual summaries of progress in smallpox eradication in the *Weekly epidemiological record* provided suitable occasions for press conferences, as did the occurrence of the last cases of smallpox in large countries and the certification of eradication in each of the countries and Regions. Efforts to obtain publicity were not without their embarrassing moments, however, the most awkward occurring on 14 October 1975, when Henderson, then on a visit to New York City, announced at a press conference that 8 weeks had elapsed since the last case of smallpox in Asia and, in view of the extent and effectiveness of surveillance, confidently stated that the last case of variola

major had been seen. Only 4 days later, however, another outbreak was found in Bangladesh (see Chapter 16).

As the programme progressed, increasing attention was given to contacts with the media (see Plate 10.16), particularly as the need for voluntary contributions became more urgent. Geneva was not so important a news centre as New York, in which there were more correspondents from many more countries. Fortunately, WHO maintained a small liaison office at the United Nations in New York with two public information officers, Ms Joan Bush and Mr Peter Ozorio, who were particularly effective in interesting the media in the programme. Among the unique ideas which they fostered were trans-atlantic press conferences, one in 1974, in which science writers and correspondents in New York and Washington interviewed Henderson in Geneva, and a second, in 1975, in which science writers in London and Dr Nicole Grasset, the adviser on smallpox eradication in the South-East Asia Region,

Plate 10.16. **A:** Lawrence K. Altman (b. 1937), correspondent for the *New York Times*, had been an epidemiologist with the measles control programme in western Africa in 1964–1965. **B:** James Magee (b. 1929) was the public information officer with the Smallpox Eradication unit, 1978–1980. **C** and **D:** Joan Bush (b. 1928) and Peter Ozorio (b. 1928) served in New York as public information officers attached to the WHO Liaison Office with the United Nations.

Plate 10.17. A montage of newspaper articles published in 1978.

answered questions from New Delhi, India.

Especially extensive and helpful press coverage was provided twice during the programme—in 1974 and 1978. The first related to epidemic smallpox in India during 1974, the most critical year for smallpox eradication in Asia (see Chapters 15 and 16). In that year, a large number of correspondents, who had come to India to report on the detonation for the first time of an Indian

Publicizing the Programme

Special issues of the WHO magazine *World health*, stamps and medals served to publicize the programme and its accomplishments. In addition to the special issues of *World health* in 1965 on the theme "Smallpox: Constant Alert" and in 1975 on "Smallpox: Point of No Return", a third special issue was published in October 1972, with the slogan "Smallpox: Target Zero" (Plate 10.18). It coincided with the launching of what was termed the "final phase" which, at that time, was expected to result in eradication by the summer of 1974. As its introduction stated: "The global eradication programme this year, for the first time, extends into every state and province of every country where the disease exists. The final phase of the campaign is beginning." Unforeseen problems, however, resulted in the final phase lasting fully 3 years longer than had been optimistically envisaged.

World health featured the subject of smallpox on two other covers—in October 1979, on the occasion of certification of eradication in the last of the endemic countries, and in May 1980 (see Chapter 24, Plate 24.2), when the Thirty-third World Health Assembly accepted the recommendation of the Global Commission for the Certification of Smallpox Eradication that "smallpox eradication has been achieved throughout the world" and that "smallpox vaccination should be discontinued in every country except for investigators at special risk".

Postage stamps and cachets on the theme of smallpox eradication and vaccination were issued by many different governments between 1965 and 1980, as illustrated in Plates 10.19–10.22. The largest number were produced in 1978, the year after the world's last outbreak, in response to a recommendation by the Universal Postal Union to its member governments that smallpox eradication should be a principal philatelic theme. In 1978, too, the United Nations issued special stamps and silver medals in recognition of the achievement (Plate 10.23).

In some countries, stamps echoed the 1965 World Health Day theme of "Smallpox: Constant Alert"; several countries of western and central Africa issued stamps between 1968 and 1972 during the course of the programme for smallpox eradication and measles control, most of which featured pictures of the jet injector; and Guinea, on completion of its WHO-supported smallpox vaccine production laboratory, issued a full set of stamps depicting various stages in the vaccine production process (see Chapter 11, Plate 11.10).

In commemoration of the declaration at the Thirty-third World Health Assembly of the global eradication of smallpox, all delegations were presented with a set of medals as mementos (Plate 10.23); these bore inscriptions in the six official languages of WHO—Arabic, Chinese, English, French, Russian and Spanish.

nuclear device, discovered that the recorded incidence of smallpox was the highest for 20 years and reported this as well. Also in 1974, a series of articles published in the *New York Times* by Dr Lawrence Altman, who was on an extended tour of India and Bangladesh, vividly documented the magnitude of the effort being made and, in turn, stimulated the interest of other publications. The consequent international publicity brought greatly increased and badly needed support for the programme from senior government officials and played an important role in obtaining additional voluntary contributions. In 1978, world-wide press coverage followed the occurrence of 2 laboratory-associated smallpox cases in Birmingham, England (see Chapter 23) at a time when the Smallpox Eradication unit was having difficulties in persuading laboratories to destroy or transfer their stocks of variola virus. As a result, national governments took a special interest in the matter and compliance followed rapidly throughout the world.

As the goal of global eradication was approached, it was important for a quite different reason to publicize the status of smallpox and its anticipated demise. With the achievement of eradication, it would be possible to discontinue routine smallpox

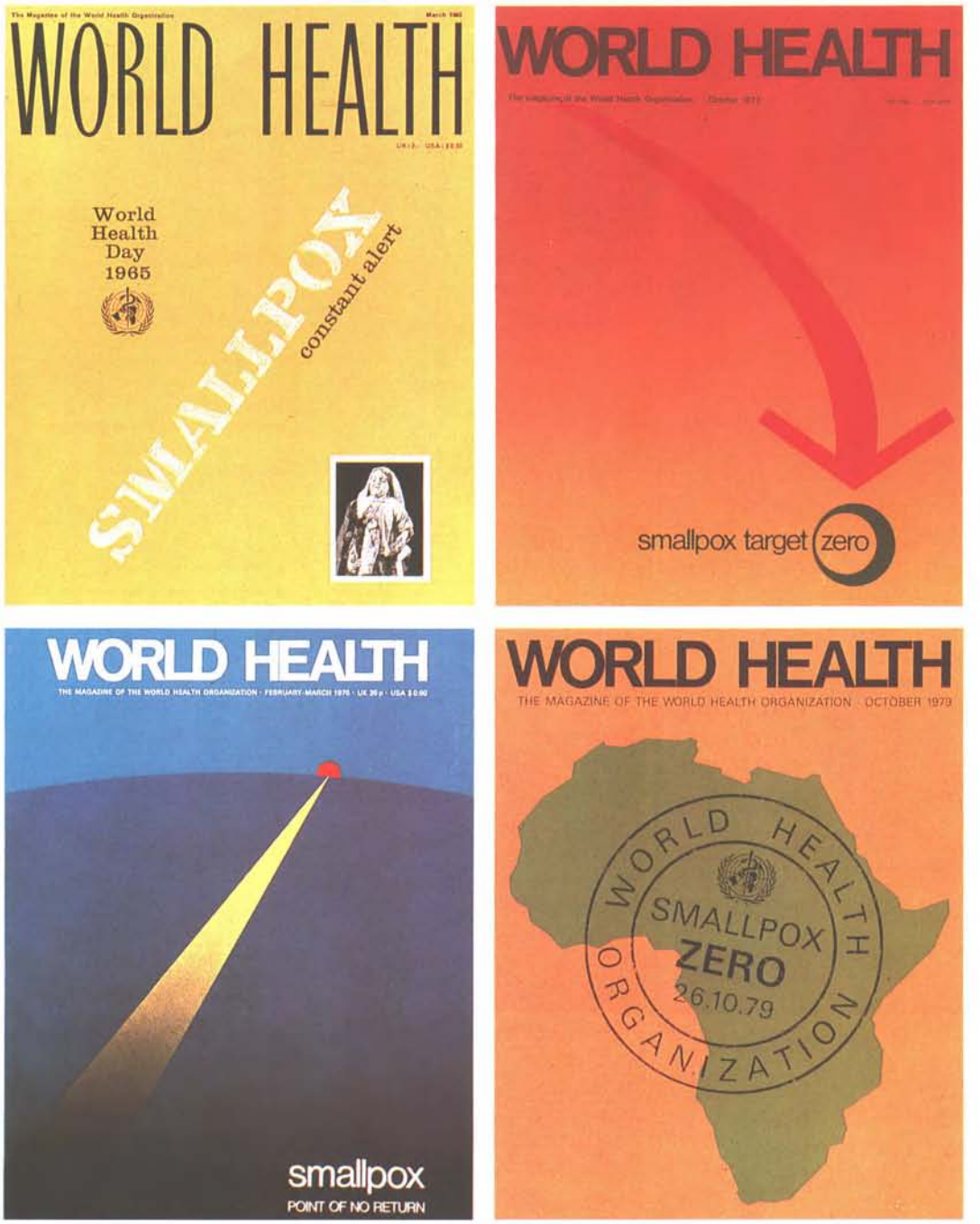

Plate 10.18. The smallpox eradication programme was presented in several issues of *World health*, an illustrated magazine published in many languages by WHO and directed to the general public.

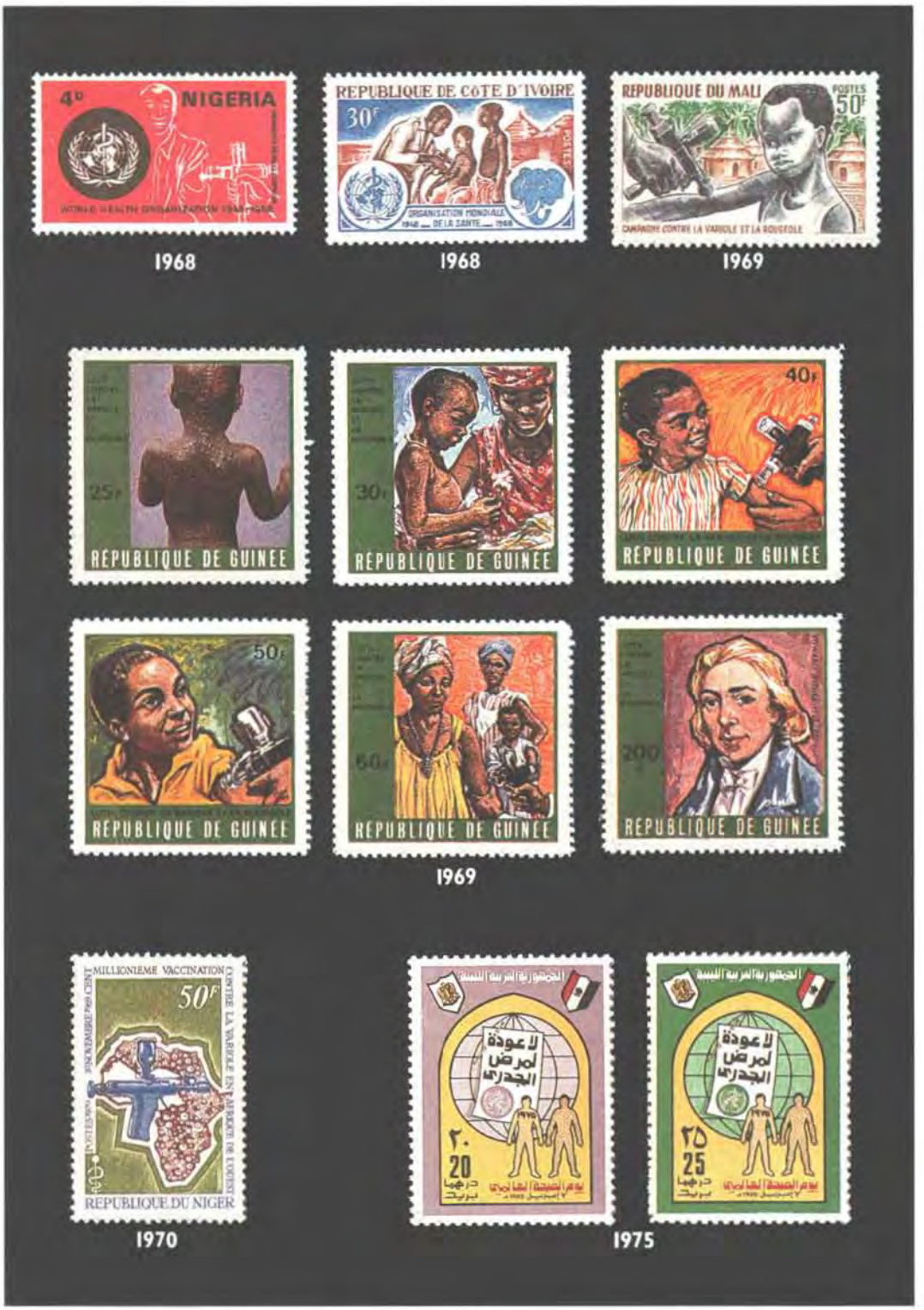

Plate 10.19. Postage stamps depicting smallpox eradication activities issued by western and northern African countries between 1968 and 1975. The Libyan stamps at the lower right take up the theme of World Health Day, 7 April 1975: "Smallpox: Point of No Return".

Plate 10.20. Postage stamps issued in 1978 by Brazil, Egypt, Iraq, Ireland, Kuwait and Lesotho to celebrate the eradication of smallpox.

Plate 10.21. Postage stamps issued in 1978 by Malaysia, Maldives, Mozambique and Nigeria to celebrate the eradication of smallpox.

Plate 10.22. Postage stamps issued in 1978 by the Philippines, Senegal, Togo, Tunisia and the United Nations to celebrate the eradication of smallpox.

Plate 10.23. **A:** A proof set, presented to the Director-General of WHO by the United Nations, of sterling silver medals struck to celebrate the eradication of smallpox. The medals were issued on 31 March 1978 in the 5 original official languages of the United Nations in conjunction with the stamps shown in Plate 10.22. **B:** In May 1980, when the Thirty-third World Health Assembly had formally declared the global eradication of smallpox, each delegation to the Health Assembly received a set of commemorative medals in the 6 official languages of WHO.

vaccination as well as the use of international smallpox vaccination certificates. Vaccination was a long-established procedure, however, and it was unlikely to be discontinued unless both health officials and the public were aware of what had been accomplished and had confidence in that achievement. A public information officer, Mr James Magee, was therefore recruited to work full time with the Smallpox Eradication unit in Geneva.

Accounts of the progress made in the Intensified Programme appeared regularly in newspapers and magazines around the world, documentary films were made by the public broadcasting service in the USA and by Japanese television, and many countries issued special stamps; commemorative medals were also struck. Eventually, the press coverage became sufficiently extensive to cause one correspondent to write in *Science* (Wade, 1980) that "WHO has found numerous occasions on which to announce the eradication of smallpox. Another such announcement, issued with some new degree of bureaucratic solemnity, is due to emerge on 12 May. Experts consider that only definitive action by the Nobel Peace Prize committee can break the chain of transmission". However, despite numerous newspaper and magazine articles in countries throughout the world and in publications as diverse as *World health*, *National geographic*, *Reader's digest*, the *Encyclopaedia Britannica* and *Scientific American*, many persons of wide reading suggested to smallpox eradication staff that the achievement was too little known and that more should have been written about it.

INTERNATIONAL SUPPORT IN CASH AND IN KIND

One of the most difficult problems was that of ensuring adequate international support for the national programmes, whose needs changed, often substantially, from year to year. In the original plan presented by the Director-General to the Nineteenth World Health Assembly in 1966, four sources of support were envisaged: (1) the WHO regular budget which, in 1967, included US$2.4 million specifically earmarked for smallpox eradication; (2) contributions to the WHO Voluntary Fund for Health Promotion, Special Account for Smallpox Eradication, which the donor could make either in cash or in kind and which, if desired, could be assigned to a specific project or country; (3) bilateral contributions; and (4) contributions from other international agencies.

The Director-General's report to the Nineteenth World Health Assembly (World Health Organization, 1966b) had forecast a need for US$48.5 million in international assistance for a 10-year programme (1967–1976), of which one-third was expected to be provided by the WHO regular budget, the balance having to be obtained from the other sources. Ultimately, international assistance from 1967 to 1979, when eradication was certified, amounted to some US$98 million, of which US$34 million came from the WHO regular budget.

Of the expected sources of support, funds from the WHO regular budget were of particular importance because they could be used wherever required and for any appropriate purpose, including personnel and travel costs, the purchase of supplies and equipment, and local operational expenses—e.g., for petrol, vehicle repairs and living allowances for national staff. These funds served to complement voluntary contributions and national resources, which sometimes provided only partial support for a country programme. In programmes in western and central Africa, for example, national governments paid staff salaries and the USA provided all other needed resources except funds for the purchase of petrol and for vehicle repairs. Comparatively small sums from the WHO regular budget for "local costs", as they were termed, enabled governments in this region to undertake eradication programmes.

Undesignated gifts of cash to the WHO Special Account for Smallpox Eradication could likewise be used for any necessary purpose and had the further advantage that balances could be carried forward from year to year. Few undesignated gifts of cash were received, however, the contributions until 1974 being primarily in the form of vaccine. During the period 1974–1978, several donors made substantial cash contributions to the voluntary fund, almost all of which were designated for use in specific countries.

Significant bilateral support was provided by the USA and the USSR, the former providing almost all international assistance for programmes in western and central Africa, and the latter supplying very large quantities of vaccine to several Asian countries and to

some in Africa. International agencies other than WHO had been expected to provide substantial assistance but little was received.

Except for the first 2 years of the Intensified Programme (1967–1968), when activities in many countries were only just beginning, the inadequacy of resources presented a continuing problem. Headquarters, regional and national staff expended considerable time and effort in attempts to obtain assistance. Frequently, however, it was found that the available funds were sufficient to sustain activities for only a few months. The difficulties, even as late as 1975, may be illustrated by an estimate prepared in July of that year of the requirements and availability of resources for 1975 and the 2 subsequent years in addition to those provided under WHO's regular budget (Table 10.3).

It had been hoped that, when it became apparent that global eradication was feasible and perhaps within reach, funds would be more readily forthcoming. Even during 1976, however, with known smallpox confined to Ethiopia, the problem did not diminish, as is shown by a memorandum of 17 February 1976 from Henderson to the Director of the WHO Regional Office for the Eastern Mediterranean:

"I concur entirely with you in regard to your appraisal of need for a WHO epidemiologist to be attached to the smallpox eradication programmes in Sudan and Somalia ... I fear that there may be unknown foci ... which may yet cause real problems ... However, I'm very concerned about our funding position ... Frankly, at this time, we simply don't have the money to fund the Ethiopian programme beyond April or May and, at the same time, funds for Bangladesh will be exhausted at the end of March. One would have expected all sorts of support at this time but we are simply not getting it."

The WHO Regular Budget

Funds from the WHO regular budget were an important component of international assistance but it was difficult to apply them optimally in the context of ever-changing global needs. Their allocation by WHO Region and by country should ideally have taken into account both relative need and the global strategy, but this was difficult given WHO's decentralized structure and administrative procedures.

The WHO budget process was best suited to the support of a diverse array of national projects, which were usually small and had financial requirements that were reasonably predictable from year to year. The Director-General's annual budget, developed over a 2-year period, was a composite of proposals prepared separately by regional directors and Headquarters units and based, in part, on requests for assistance received from countries. Each regional director drew up a detailed budget specifying personnel and other costs for each project in each country and in the regional office. These project proposals were usually not reviewed by the relevant technical units at Headquarters, which similarly submitted detailed budget proposals of their own, broken down by permanent staff and consultant costs, as well as proposed expenditures for travel, meetings and other items. Following a review of the proposals by the Director-General and the assistant directors-general, an overall proposed programme and budget for the entire Organization was set out in detail for consideration by the Executive Board at its January session and by the World Health Assembly, which was usually convened in May—7 months before the beginning of the next financial year. The Smallpox Eradication unit had no indication as to the total allocations available for smallpox eradication each year until the budget volume was distributed.

Table 10.3. Estimated requirements and available resources as at July 1975, in addition to those provided under the WHO regular budget, 1975–1977 (US$)

Year	Amount needed	Available	Deficit
1975	1 975 000	1 445 000	530 000
1976	1 560 000	345 000	1 215 000
1977	1 450 000	345 000	1 105 000

The budget was almost invariably approved by the Health Assembly as presented, after which each regional director could transfer WHO regional resources from one project to another as need and opportunity presented. Funds could be transferred from one region to another only by the Director-General, but such transfers were seldom made.

In 1967, more than 90% of all the funds voted for smallpox eradication by the Health Assembly were allocated by the Director-General to the 4 regions in which endemic smallpox was then present (Table

10.4), only a small amount (about 8%) being provided to support Headquarters or interregional activities.

Because of the nature of the budget process, the Smallpox Eradication unit decided that the best way of achieving the optimum allocation of resources was through close collaborative planning with regional office staff. If this could be achieved, it was believed that a consensus on needs and priorities could be reached which would be reflected in annual budgets, and it would be possible to provide up-to-date information to regional directors so that transfers of funds could be made where required. Thus, each year, a planning meeting was scheduled which was attended by the officer responsible for smallpox eradication in each regional office together with senior Smallpox Eradication unit staff. Although it was usually possible to reach a consensus as to priorities and allocations of resources, the subsequent execution of agreed plans ranged from excellent to indifferent.

During the first 2 years of the Intensified Programme, the full utilization of appropriated funds was a major concern. At the Nineteenth World Health Assembly, in 1966, a number of delegates had proposed a budget of US$1 million for smallpox eradication, since they doubted whether the Organization could fully utilize US$2.4 million. Although the Director-General had assured them that the larger amount could be well used, this was, in fact, not easily accomplished. Before funds could be obligated, country plans and lists of the supplies and equipment needed had to be drawn up. With full-time advisers for smallpox eradication in only 2 of the WHO regions, and those not the most seriously affected, the task was not easy. Yet, if the funds were not fully expended, it would reflect poorly on the Organization. In 1967 and 1968, a lengthy correspondence was carried on with each of the WHO regions concerned, analysing and reanalysing budgets and obligations and repeatedly urging the regions to develop agreements and obligate funds as soon as possible.

The full obligation of allocated funds would have been facilitated by the procurement of a reserve fleet of vehicles, to be dispatched as they became needed by countries. This was a practice followed by UNICEF and one which would have alleviated serious delays in starting programmes, which were often caused by 12–18-month delivery times for vehicles. A proposal to this effect, however, was not accepted.

Table 10.4. Director-General's budgetary allocations for smallpox eradication for 1967 and estimated actual expenditure (US$)

Region	Budget allocations for smallpox	Estimated actual expenditure
Africa	658 428	460 090
Americas	629 000	742 063
South-East Asia	815 030	295 281
Europe	0	0
Eastern Mediterranean	246 706	573 999
Western Pacific	2 000	55 831
Headquarters and interregional	210 640	268 552
Total	2 561 804	2 395 816

In 1967, plans were quickly developed in the Region of the Americas and the Eastern Mediterranean Region but far less was accomplished in Africa and South-East Asia. As the year progressed, it became apparent that the funds committed in these latter regions would fall substantially short of those allocated. This problem, however, was solved in a manner that served indirectly to provide the Smallpox Eradication unit with added discretionary resources for emergency needs. Towards the end of 1967, the Regional Director for South-East Asia was persuaded to release funds allocated for use elsewhere and the Director-General approved the transfer. Some were transferred to the Regions of the Americas and the Eastern Mediterranean and some were used for the purchase of large numbers of the new bifurcated needles and jet injectors. The subsequent ability to dispatch bifurcated needles and jet injectors (as well as vaccine) promptly to countries in need was of great help in carrying out programme activities. The Regional Director for Africa chose not to release his unobligated funds and, in December, at the end of the financial year, they were returned to Headquarters. Fortunately, however, it proved possible to recover them for the programme, thanks to the Division of Budget and Finance. Cash contributions to the WHO Voluntary Fund for Health Promotion's Special Account for Smallpox Eradication had not been large, but a moderate sum had accumulated by 1967. In that year, virtually all these funds had been spent on travel, consultants and training materials. The unobligated funds from the African Region were used to cover these

expenditures, and the cash balance in the special account was restored and carried forward to the following year. Almost every year thereafter unobligated funds from the regions enabled the cash balance in the special account to be largely restored, thus providing a small but immensely valuable cash reserve to supplement the meagre discretionary funds otherwise available for smallpox eradication through Headquarters accounts.

By 1969, most countries had begun eradication programmes and the problem of lack of funds replaced that of utilizing budgeted allocations. As Henderson wrote to the regional smallpox adviser in the Americas (21 February 1969):

"I am concerned about the problem of money this year for I am afraid we will be very hard pressed indeed. We could use substantially more in the African Region; the Eastern Mediterranean Region has requested some additional [funds] ... and the South-East Asia Region, if the Indian programme accelerates as expected, could use everything we have. I am afraid the honeymoon is over with respect to finances."

It was also pointed out that Brazil, the only endemic country in the Region of the Americas, had already received substantial resources, including funds released in 1967 by the South-East Asia Region, and it was suggested that the Region of the Americas might reciprocate by releasing some of its funds for use elsewhere. However, such transfers of funds were not customary and this proposal was rejected, as were similar subsequent ones.

To achieve a more appropriate distribution of funds, the next best approach seemed to be to attempt to change the regional allocations from year to year to reflect more accurately the relative balance of needs in the different regions. The first allocations, in 1967, had necessarily been arbitrary ones, since it had not been possible at that time to make accurate estimates of need by region. Up to 1970, the allocations remained essentially unchanged but, by then, it was increasingly apparent that far less would be required in the Americas during future years but far more in Asia and Africa and that a reapportionment based on longer-term requirements was needed. Throughout 1970, Smallpox Eradication unit staff worked closely with those in the regions to reach a consensus on future needs. Towards the end of the year, however, the unit was informed that proposals based on these analyses would not be approved by the Director-General. Although the exercise had proved futile, it was hoped that it might still be possible at least to reduce the allocation to the Americas and to increase it in other regions. In a memorandum (dated 30 December 1970) to his Assistant Director-General, Henderson pointed out:

"Plentiful funds are available in the Region of the Americas as confirmed in discussions in Washington during December ... all concerned feel confident that smallpox transmission in the Americas will be interrupted in 1971. It is proposed that smallpox eradication funds be used to strengthen surveillance activities [in the Americas] ... However, even if gilt-edged support is provided to this enterprise, it is agreed that it would be difficult to expend more than $250–300 000 per year [of a budgeted US$569 000]."

The proposed change in allocation was discussed with the Regional Director for the Americas, who agreed with the budget analysis but pointed out that he needed more funds for malaria eradication and asked for some sort of trade-off so as to maintain his regional budget at a more constant level. The Director-General decided, however, not to alter the regional allocations for smallpox eradication for 1971 and, from 1972, the practice of identifying a specific allocation for smallpox eradication was discontinued. This ended the efforts to develop plans for the better deployment of funds from WHO's regular budget. After 1971, it was no longer required that a prescribed minimum amount should be spent on smallpox eradication; the regional directors allocated funds from their overall allotments on the basis of their sense of the programme's priority in relation to the other needs in their regions.

When inflation is taken into account, as was customary each year in preparing WHO's overall budget, the Organization's annual expenditures for the programme up to 1976 were close to the appropriation of US$2.4 million originally approved by the Health Assembly in 1966 (Table 10.5). However, as the number of endemic countries decreased, increasing problems were encountered in obtaining the support necessary to complete the programme and to permit certification, as is shown by a memorandum of 6 January 1975 from Henderson to the Director-General:

"We may face some difficult questions at the Executive Board in regard to the smallpox budget

which we should be prepared for. In November, a special appeal was made by the Director-General for additional funds for the smallpox programme. The importance of the programme and the high priority given to it by the Organization was emphasized. Only $2.1 million of the $3.3 million requested has so far been received but we know of at least five additional countries which have indicated that additional support might be forthcoming.

"The difficult problem about which questions will almost certainly be forthcoming is why the Organization cut the smallpox allocations (by 29%) if it accords the programme such high priority and is asking for special donations. The budget cuts are evident not only in the Regions but also at Headquarters.

"As the first knowledge which I had in regard to the budget levels was when I received Official Records No. 220 [Proposed Programme and Budget for 1976–1977], I find it difficult to contrive a suitable answer which might be proposed. And yet, an inappropriate response could be most damaging, as I'm sure you would agree."

Questions were asked by the Board but the budget was not changed.

Other Types of Assistance to Programmes

As has been mentioned earlier, it was expected that two-thirds of the total costs of the smallpox eradication programme would be met by international agencies other than WHO and by voluntary contributions to governments or to the Special Account for Smallpox Eradication in the WHO Voluntary Fund for Health Promotion. In view of the level of support for smallpox eradication during 1959–1966 (see Chapter 9), this originally seemed to be an unrealistic expectation, but such contributions eventually amounted to US$66.9 million over the period 1967–1979 (Table 10.6).

The different types of contribution are, for the most part, considered together in this section, since it is somewhat arbitrary to identify some as bilateral contributions, some as support to the Special Account for Smallpox Eradication and some as contributions by other international organizations. For example, the substantial cash contributions made by Denmark, Norway and Sweden to programmes in Bangladesh and India during 1974–1977 were provided through the special account for administrative convenience but were a part of the bilateral assistance funds already allocated for use in these countries. Similarly, support from two United Nations organs, the United Nations Emergency Operation (UNEO) in Bangladesh in 1972 and the Office of the United Nations Disaster Relief Co-ordinator (UNDRO) in Somalia in 1977, consisted of supplies and equipment provided by national governments in response to emergency appeals rather than of funds from the established budgets of these organs.

Throughout the programme, an effort was made to account for and place a cash value on the support provided by different agencies. The data as presented, however, suggest a greater precision and completeness in accounting than is, in fact, the case. Many of the contributions were in kind rather than in cash. When a contribution was provided through the Voluntary Fund for Health Promotion, the donor was responsible for

Table 10.5. Expenditure on smallpox eradication from the WHO regular budget in real and constant dollars, 1967–1979 (US$)

Year	Headquarters	Interregional	African Region	Region of the Americas	South-East Asia Region	Eastern Mediterranean Region	Western Pacific Region	Total (US$)	Total in terms of 1967 US$
1967	157 076	111 476	460 090	742 063	295 281	573 999	55 831	2 395 816	2 395 816
1968	180 086	102 511	722 141	815 574	555 634	348 886	3 940	2 728 772	2 647 209
1969	177 966	163 498	951 237	669 142	273 406	649 938	4 491	2 889 678	2 716 933
1970	217 060	83 153	919 020	579 164	460 709	722 587	6 208	2 987 901	2 719 976
1971	219 047	123 574	942 962	503 408	573 279	702 999	4 767	3 070 036	2 652 910
1972	240 460	137 430	1 000 040	481 819	787 081	654 801	2 858	3 304 489	2 702 841
1973	308 490	235 606	694 770	191 259	1 002 489	735 975	0	3 168 589	2 445 327
1974	281 440	273 912	278 599	143 831	1 110 656	960 030	2 838	3 051 306	2 213 845
1975	292 089	408 083	156 130	117 687	1 546 243	540 669	0	3 060 901	2 079 423
1976	480 037	988 866	110 323	0	601 825	1 366 648	0	3 547 699	2 265 525
1977	415 112	1 137 518	26 048	0	439 507	163 130	0	2 181 315	1 304 056
1978	310	504 200	6 944	0	114 646	109 872	0	735 972	409 988
1979	0	344 855	0	0	67 777	30 142	0	442 774	228 604
Total	2 969 173	4 614 682	6 268 304	4 243 947	7 828 533	7 559 676	80 933	33 565 248	26 782 452

Table 10.6. Contributions for smallpox eradication in cash or in kind to the WHO Voluntary Fund for Health Promotion, Special Account for Smallpox Eradication, and from sources of bilateral support, 1967–1979 (US$)

Contributor	Total	Voluntary Fund for Health Promotion, Special Account for Smallpox Eradication		Bilateral support (cash and kind)
		Cash	Kind	
Australia	33 625	33 625	–	0
Austria	75 500	5 000	–	70 500
Argentina	13 275	–	13 275	0
Belgium	378 800	–	378 800	0
Brazil	128 925	–	128 925	0
Cameroon	707	707	–	0
Canada	2 505 061	1 306 779	1 156 282	42 000
Colombia	3 002	–	3 002	0
Czechoslovakia	41 118	–	41 118	0
Denmark	1 083 062	1 083 062	–	0
Finland	110 623	19 663	90 960	0
German Democratic Republic	26 417	–	26 417	0
Germany, Federal Republic of	503 767	127 004	–	376 763
Ghana	3 273	3 273	–	0
Greece	23 000	23 000	–	0
Guinea	18 529	–	18 529	0
Hungary	33 500	–	33 500	0
India	503 691	–	207 291	296 400
Iran	874 000	500 000	374 000	0
Japan	634 198	268 400	223 598	142 200
Jordan	140	–	140	0
Kenya	168 000	–	168 000	0
Kuwait	12 992	12 992	–	0
Luxembourg	6 541	6 541	–	0
Monaco	2 419	–	2 419	0
Netherlands	2 803 133	2 613 393	177 870	11 870
New Zealand	10 500	–	10 500	0
Nigeria	16 036	16 036	–	0
Norway	998 530	998 530	–	0
Peru	3 000	–	3 000	0
Philippines	5 000	–	5 000	0
Poland	3 500	–	3 500	0
Saudi Arabia	200 000	200 000	–	0
Sweden	15 689 584	15 408 504	281 080	0
Switzerland	372 169	118 659	219 910	33 600
Thailand	3 565	–	3 565	0
Uganda	12 077	12 077	–	0
Union of Soviet Socialist Republics	8 805 610	–	3 531 913	5 273 697
United Kingdom	1 020 924	1 010 924	–	10 000
United States of America	24 974 003	6 339 900	1 258 408	17 375 695
Yugoslavia	26 000	–	26 000	0
Zaire	2 500	2 500	–	0
Council of Arab Ministers' Fund for Health Development	20 350	–	20 350	0
Japan Shipbuilding Industry Foundation	1 769 344	1 769 344	–	0
OXFAM	103 104	3 104	–	100 000
Tata Iron & Steel Co. Ltd (India)	536 399	–	–	536 399
Other	52 238	26 806	25 432	0
Subtotal	64 611 731	31 909 823	8 432 784	24 269 124
UNDP (United Nations Development Programme)	299 344	–	–	299 344
UNDRO (Office of the United Nations Disaster Relief Coordinator)	470 849	–	–	470 849
UNEO (United Nations Emergency Operation)	750 000	–	–	750 000
UNICEF (United Nations Children's Fund)	427 878	–	–	427 878
UNROD (United Nations Relief Operation, Dacca)	415 500	–	–	415 500
Subtotal	2 363 571	–	–	2 363 571
Total	66 975 302	31 909 823	8 432 784	26 632 695

assigning a cash value to it but different donors assigned different values to the same product. For example, most vaccine was valued at US$10–16 per 1000 doses but values as high as US$256 per 1000 doses were assigned by some donors. The average value for all vaccine contributed worked out at US$17 per 1000 doses, although estimates of the actual costs of vaccine production in the industrialized countries in the early 1970s were in the range of US$30–40 per 1000 doses.

It may be noted that in several instances the amounts in Table 10.6 are different from those recorded by the Global Commission for the Certification of Smallpox Eradication in Annex 16 to its Final Report (World Health Organization, 1980). The differences are the consequences of adjustments made in the light of more recent information. In addition, Annex 16 included the value of some bilateral contributions made before 1967 (notably by the USA and the USSR) and of cash and vaccine pledged during the period 1967–1979 by India, the USSR and the Japan Shipbuilding Industry Foundation but received after 1979; these amounts have been omitted from Table 10.6.

An attempt was also made to place a cash value on the services of volunteer personnel. For accounting purposes, a figure of US$750 per month was assigned, an estimate provided by one of the principal donor governments. This figure, as well as a number of other approximations that were made, undoubtedly understates to some degree the value of gifts in kind. All but impossible to estimate, and not included here, is the value of services provided by many local, non-governmental groups, such as the League of Red Cross and Red Crescent Societies; Kiwanis, Lions and Rotary Clubs; youth groups, such as the Boy Scouts and Girl Guides; and missionary groups. In a number of countries such groups were most helpful in organizing vaccination campaigns, mobilizing public support and, sometimes, performing vaccinations. A few contributed funds in support of local programmes, although in comparison with national and international contributions, the cash value of all such contributions was not large.

Although voluntary contributions were recognized by the Health Assembly to be an essential adjunct to the WHO regular budget, such support was difficult to obtain. Every year, Health Assembly resolutions requested all countries to provide additional support and every year the Director-General sent letters to all Member States and to relevant international agencies, referring to the Health Assembly resolution and asking for help. Smallpox eradication programme staff regularly met potential donors at the World Health Assembly and during special visits to national capitals and embassies; special meetings of potential donors were convened; and influential national figures who were sympathetic to the programme were regularly contacted to seek their good offices in obtaining support. Despite these efforts and despite the fact that the eradication of smallpox would be of great benefit to all countries, contributions were modest at best. This may have reflected a certain scepticism as to the feasibility of eradication; however, it also reflected the fact that WHO, except for malaria eradication, had not previously been active in seeking supplementary contributions and governments were unaccustomed to making them. As Table 10.7 shows, except in respect of malaria eradication, the contributions to the special accounts that made up the Voluntary Fund for Health Promotion did not exceed US$2 million in any year until 1968, and of all the contributions made between 1967 and 1975, 18% were for smallpox eradication.

Vaccine for the programme was obtained entirely from voluntary contributions or local production. From 1967 to 1979, 27 countries contributed 407 million doses of vaccine to the Voluntary Fund, more than 60% of this coming from the USSR. Although industrialized countries provided most of the donated vaccine, notable contributions of vaccine were also made by Argentina, Brazil, Colombia, Guinea, India, Iran, Kenya, Peru, Philippines and Thailand.

Efforts to obtain support from UNICEF and the United Nations Development Programme (UNDP) proved disappointing, although both agencies had previously given significant support to other WHO programmes, as well as some support for smallpox eradication before 1967. Between 1967 and 1972, UNICEF provided US$427 878 for vaccine and vaccine production equipment but none thereafter—a policy reflecting its disappointment with the lack of progress in malaria eradication and its decision not to support another attempt to eradicate a disease. The possibility of support from UNDP was explored with the resident

Table 10.7. Contributions in cash or in kind to the WHO Voluntary Fund for Health Promotion or to special accounts,[a] by year, 1956–1979 (US$)[b]

Year	Malaria eradication	Smallpox eradication	Other	Total
1956	68 096	–	–	68 096
1957	5 046 909	–	–	5 046 909
1958	169 506	285 000	300 000	754 506
1959	6 284 766	–	500 000	6 784 766
1960	1 202 317	104 010	622 488	1 928 815
1961	4 464 094	96 000	1 266 674	5 826 768
1962	590 437	3 800	573 115	1 167 352
1963	2 718 815	5 060	1 572 479	4 296 354
1964	163 300	316 694	1 148 857	1 628 851
1965	86 890	24 936	843 843	955 669
1966	77 225	40 780	1 449 518	1 567 523
1967	37 050	202 305	611 747	851 102
1968	46 711	313 233	2 233 294	2 593 238
1969	36 854	239 457	1 408 438	1 684 749
1970	52 977	337 820	2 352 518	2 743 315
1971	85 339	810 708	5 957 930	6 853 977
1972	157 009	780 632	4 368 568	5 306 209
1973	252 392	1 288 137	10 683 838	12 224 367
1974	257 823	4 533 310	11 032 822	15 823 955
1975	1 307 009	10 522 835	20 535 705	32 365 549
1976	388 367	9 448 523	22 393 979	32 230 869
1977	973 150	5 272 392	28 886 320	35 131 862
1978	7 134 651	5 690 337	35 129 741	47 954 729
1979	2 117 617	902 918	29 101 543	32 122 078
Total	33 719 304	41 218 887	182 973 417	257 911 608

[a] Special accounts were amalgamated, as sub-accounts, into the Voluntary Fund for Health Promotion when that was established by the World Health Assembly in 1960 (except for the Malaria Eradication Special Account, which was placed in the Voluntary Fund in 1964).

[b] Excludes income from interest, revenue from sales, and savings.

representatives in several countries, but lack of interest, the complexities involved in developing suitable proposals and the delays in securing their approval restricted support to US$299 344.

Between 1967 and 1970, over half of all international expenditure on smallpox eradication was met by bilateral contributions (Table 10.8), representing primarily United States support for the programme in western and central Africa and contributions of vaccine by the USSR to India and several smaller Asian countries. With the achievement of smallpox eradication in western and central Africa in 1970, support for that programme began to be phased out and India, during the early 1970s, began to rely increasingly on domestically produced vaccine. Bilateral contributions diminished proportionately, and after 1972 exceeded US$1 000 000 only in 1974 and 1975.

Expenditure from the Special Account for Smallpox Eradication up to the end of 1973 was accounted for primarily by the distribution of donated vaccine. The amounts increased steadily over the years, reaching US$845 150 in 1973. Two-thirds of the expenditure on smallpox eradication in 1973, however, were met by WHO's regular budget.

Contributions to the Voluntary Fund increased significantly from 1974 onwards. In the autumn of 1973, smallpox eradication activities had been intensified in Asia, but the problems encountered in India proved far more formidable than had been anticipated (see Chapter 15) and, in response to special appeals for assistance, Sweden began to contribute substantial sums to the Voluntary Fund for use in that country, amounting in total to more than US$9 million during 1974–1976. As difficulties mounted in Bangladesh as well, Sweden, and later Norway and Denmark, joined together to provide more than US$5 million for its programme. Substantial additional assistance for India was also provided by the Tata Iron and Steel Company of India, by Iran and by OXFAM.

In 1974, it was also possible to intensify the programme in Ethiopia, the only endemic country outside Asia, thanks to support from the United States Public Health Service, which began to make funds available for leasing helicopters, nearly US$2 million being provided for this purpose from 1974 to 1977. AID contributed US$3 million to the Voluntary Fund in 1976–1977 in support of the Ethiopian programme and additional assistance was provided by Australia, Austria, Finland, the Federal Republic of Germany and Japan. Finally, with the reintroduction of smallpox into Somalia in 1976 (see Chapter 22), special appeals for funds brought contributions from the USA and from UNDRO. Meanwhile, cash contributions which could be used wherever required were provided by Canada, the Netherlands, the United Kingdom, Switzerland and the Japan Shipbuilding Industry Foundation.

By 1977, the year in which the last endemic case occurred, the Voluntary Fund covered more than 70% of all expenditures; during the period of certification activities, 1978–1979, WHO regular budget allocations were sharply decreased and the coverage by the Voluntary Fund increased to 80–90%.

Although the increase in voluntary contributions from 1974 onwards coincided with a growing recognition of the feasibility of global smallpox eradication, the donations proved to be almost as difficult to obtain as in

earlier years. A review of the origin and history of each of the contributions shows that personal, often repeated, appeals by individual members of the smallpox eradication programme staff had to be made in order to obtain each contribution.

SUPPLY OF VACCINE AND VACCINATION INSTRUMENTS

The availability at all times of satisfactory freeze-dried vaccine and vaccination instruments was essential to the successful execution of the programme. Without vaccine and bifurcated needles or jet injectors, programme staff could do nothing; with them, methods could usually be devised to deal, at least to some extent, with shortages of transport and equipment, and so sustain both momentum and morale. Because of the importance of vaccine and vaccination instruments, Chapter 11 is devoted exclusively to the subject. Here, we summarize the methods used to ensure that both were readily available to all endemic countries and to those adjacent to them.

Vaccine Requirements

It had originally, but erroneously, been assumed that the provision of adequate quantities of suitable freeze-dried vaccine would not present a major problem. It was believed that, for most endemic countries, if sufficient vaccine were not already available, it would either be provided in the form of bilateral contributions or soon be produced in the endemic countries themselves. Additional requirements would be met through contributions made through the Voluntary Fund for Health Promotion, the pledged annual contribution of 25 million doses by the USSR being considered almost sufficient for this purpose.

From what was known in 1967, adequate supplies of vaccine appeared to be available. In the Americas a number of laboratories were already producing freeze-dried vaccine and an agreement was signed by the Pan American Health Organization with Connaught Laboratories of Canada to provide for continuing consultation, the training of technicians and the monitoring of vaccine throughout that region. It seemed, therefore, that this region was already self-sufficient, or soon would be. In the African Region, the programme in western and central Africa was being carried out with the assistance of the USA, which provided the necessary vaccine to 20 countries. In virtually all other countries, some type of vaccination programme was in progress and it was assumed that many had already obtained satisfactory vaccine from some source, although it was recognized that additional vaccine would be required if the programmes were to be intensified. In the South-East Asia Region, only Nepal and possibly Indonesia among the endemic countries appeared to require vaccine. India's needs were being met by domestic production and bilateral contributions from the USSR.

Table 10.8. International expenditure on smallpox eradication, 1967–1979 (US$)

Year	WHO regular budget	Voluntary Fund for Health Promotion, Special Account for Smallpox Eradication	Other organs of United Nations system	Bilateral support	Total
1967	2 395 816	194 889	526 476	3 911 700	7 028 881
1968	2 728 772	255 927	116 774	4 163 680	7 265 153
1969	2 889 678	233 635	83 713	4 334 060	7 541 086
1970	2 987 901	375 434	61 644	3 918 307	7 343 286
1971	3 070 036	608 403	34 772	2 377 650	6 090 861
1972	3 304 489	727 581	448 100	1 397 627	5 877 797
1973	3 168 589	845 150	–	997 655	5 011 394
1974	3 051 306	3 127 169	–	1 086 907	7 265 382
1975	3 060 901	8 065 031	631 696	1 494 282	13 251 910
1976	3 547 699	6 629 430	118 304	189 313	10 484 746
1977	2 181 315	6 724 347	470 849	9 780	9 386 291
1978	735 972	4 364 812	–	388 163	5 488 947
1979	442 774	5 491 229	–	–	5 934 003
Total	33 565 248	37 643 037	2 492 328	24 269 124	97 969 737

Afghanistan and Burma were also receiving vaccine from the USSR. In the Eastern Mediterranean Region, Pakistan was thought to be producing sufficient vaccine for its own needs in a laboratory in Dhaka, and the quantities required for Ethiopia, Somalia, the Sudan and Yemen were thought not to be great.

In 1967, a detailed survey of the amount and quality of vaccine being produced throughout the world revealed that the situation was much less satisfactory than had been thought. It was discovered that much of the vaccine then in use was produced by laboratories which did not test it for stability, while some laboratories determined potency simply by vaccinating a group of young children. When tested by the 2 WHO reference laboratories, much of the vaccine from developing countries and some from industrialized ones did not meet the international standards.

During the first 2–3 years of the Intensified Programme, the provision of vaccine was not a major problem, however, because of the time required for national programmes to organize activities aimed at increasing substantially the number of vaccinations performed. Of the countries in which major programmes began in 1967, Brazil produced sufficient vaccine for its own needs and, as has already been mentioned, the countries of western and central Africa were supplied by the USA. To ensure an adequate supply of vaccine of proven potency to meet the needs of other countries, a number of measures had to be taken quickly: (1) vaccine production laboratories in endemic countries were supported by the provision of consultants, equipment and production manuals; (2) the WHO reference laboratories agreed to test all batches of vaccine produced by newly established laboratories and to participate in research and other activities which would enhance and/or simplify production methods; (3) a system of international quality control was established for all vaccine used in the Intensified Programme, whether locally produced or donated through bilateral assistance or by WHO; (4) vaccination devices were tested and introduced which used less vaccine than conventional techniques; and (5) additional contributions of vaccine were sought. As a result, sufficient vaccine of adequate quality was eventually ensured for every endemic country, although for many years reserve supplies remained perilously low.

Plate 10.24. Ryoichi Sasakawa, President of the Japan Shipbuilding Industry Foundation, presents a cheque for US$500 000 to F. J. Dy, Director of the WHO Regional Office for the Western Pacific in November 1975. Masami Tanaka, Minister of Public Health of Japan, stands between them. The Foundation later increased its support to WHO for smallpox eradication to a total of nearly US$1.8 million, the largest amount given by a nongovernmental organization.

Support for Production Laboratories in Endemic Countries

Of the commonly used vaccines, smallpox vaccine was the easiest to produce and laboratories already existed in a number of developing countries. Priority was given to the support of laboratories in the countries with the largest populations in order both to improve the quality of their vaccine and to increase their capacity, in the expectation that voluntary contributions would meet the needs of others. A first step was to simplify and standardize production methods. The principles on which vaccine production was based were similar throughout the world, but techniques differed widely from one laboratory to another. In 1968, therefore, a meeting of the most experienced vaccine producers was convened to develop a manual (SE/68.3 Rev.2) which described in detail the optimum production procedures. Selected consultants then repeatedly visited laboratories in the endemic countries to help them to improve methods and expand capacity. On the basis of their recommendations, additional equipment and supplies were provided. Vials of seed virus for use in production, as well as

reference specimens for testing, were prepared and distributed by the National Institute of Public Health, Bilthoven, Netherlands; when the laboratories began production, batches of vaccine were tested by one or the other of the two WHO reference laboratories.

Year by year, the quantity of vaccine produced in the developing countries increased and its quality improved. In the South-East Asia Region, Burma became self-sufficient in 1969 and Indonesia in 1970; India's 4 laboratories slowly but steadily increased the quantity and quality of their vaccine. The laboratory in Dhaka likewise increased production to provide sufficient vaccine for East Pakistan, although some additional supply had to be provided during the intensified programme in 1973–1975, in what was then Bangladesh. In the African Region, support was provided to laboratories in Guinea, Kenya and Nigeria in the hope that they might serve as producers for large regions of eastern and western Africa. Kenya, by late 1968, was able to produce sufficient vaccine for several countries in eastern Africa; the laboratory in Guinea took much longer to begin production and never succeeded in producing large quantities; the laboratory in Nigeria produced only a few satisfactory experimental batches. In the Americas, most of the countries conducting programmes quickly became self-sufficient and contributed vaccine to others requiring it. Brazil, as noted above, produced sufficient vaccine for its own needs and, although many batches did not meet international standards, especially for stability, the vaccine was effective provided that it was kept cold until the time of application. The Eastern Mediterranean Region was ultimately to require the largest amounts of vaccine. Efforts to establish a laboratory in Pakistan, the country with the largest population in the region, failed because of national administrative problems, but by 1973 sufficient vaccine to meet most of Pakistan's needs was being provided by Iran. Assistance was also given to laboratories in Ethiopia, Iraq and the Syrian Arab Republic, but none of these succeeded in producing more than small quantities of satisfactory freeze-dried vaccine.

By 1971, approximately 250 million doses of vaccine were being produced annually in the endemic regions, and by then all the vaccine used in national programmes, except in Brazil, met international standards.

Vaccine Donations

Most of the contributed vaccine was provided under bilateral agreements by the USSR, which donated more than 1400 million doses from 1958 to 1979. The USA provided more than 190 million doses, primarily to the western and central African countries, also under bilateral agreements. Contributions from other countries usually amounted to no more than a few million doses each year (see Chapter 11, Table 11.15 for the quantities contributed to WHO between 1967 and 1984). In part, this was because most industrialized countries produced their own vaccines in small national or quasi-national laboratories. Most produced little or no freeze-dried vaccine, preferring instead the glycerolated liquid vaccine, which could be dispensed more conveniently in single-dose capillaries. Although the vaccine had to be kept constantly under refrigeration, this caused little difficulty for the industrialized countries.

Except for the vaccine provided under bilateral agreements by the USSR and the USA, virtually all vaccine contributions were made through the WHO Voluntary Fund for Health Promotion. Until 1967, arranging for the acceptance and shipment of vaccine contributed to WHO was complicated and time-consuming, usually requiring 6–18 months (see Chapters 9 and 11). Several measures were therefore taken to reduce the processing interval to only 6–8 weeks. The Smallpox Eradication unit assumed responsibility for arranging for tests of batches of vaccine proposed for donation and the National Institute of Public Health, Bilthoven, agreed to examine specimens as soon as received. Specimens were shipped promptly and the results reported by telex or telephone. One obstacle to rapid processing was the requirement that vaccine titres should be determined after incubation for 4 weeks at 37 °C. When it was shown in 1969 that all vaccine batches with an adequate titre after incubation for 1 hour at 100 °C also met conventional stability tests (Arita, 1973), it was possible further to reduce the time required for testing by 4 weeks. Another problem had been that of arranging for the prompt shipment of vaccine from donor laboratory to recipient country. Many donors waited until vaccine was requested before beginning production but, even when it was available in stock, many delays occurred in arranging for international shipment. WHO

Table 10.9. Quantities of vaccine supplied annually from vaccine donated to WHO (thousands of conventional doses)[a]

Country or organization	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Africa														
Benin	0	0	0	0	0	0	0	2	0	0	0	672	0	674
Botswana	0	0	0	0	245	445	100	190	194	256	292	220	237	2 179
Burundi	1 000	200	0	725	758	315	0	250	0	177	0	64	0	3 489
Cameroon	0	0	0	0	0	0	300	0	0	0	830	0	0	1 130
Cape Verde	0	0	0	0	0	0	0	0	155	80	64	6	32	337
Central African Republic	0	0	0	0	0	0	120	0	0	0	0	224	0	344
Chad	0	0	0	0	0	0	300	0	0	0	0	360	0	660
Comoros	0	0	0	0	0	0	0	0	0	120	100	0	0	220
Congo	0	0	0	0	0	0	190	10	0	0	0	496	0	696
Djibouti	0	0	0	0	0	0	0	0	0	0	0	100	0	100
Equatorial Guinea	0	0	17	0	0	0	0	0	0	0	64	0	0	81
Ethiopia	0	0	0	315	4 323	2 432	1 998	2 468	2 384	5 720	3 048	560	25	23 273
Gabon	0	0	0	0	0	100	65	0	0	0	0	0	0	165
Gambia	0	0	0	0	0	0	0	0	0	0	46	32	0	78
Ghana	0	0	0	0	0	0	0	22	0	10	18	0	0	50
Guinea	749	0	0	0	0	0	0	0	0	0	0	0	0	749
Guinea-Bissau	0	0	0	0	0	0	0	0	100	0	0	0	0	100
Lesotho	0	0	0	210	70	105	20	0	40	90	152	48	96	831
Liberia	250	0	0	0	0	0	20	0	0	0	0	128	0	398
Malawi	0	508	300	1 007	525	1 000	500	1 007	953	500	610	600	315	7 825
Mali	100	0	0	0	0	0	810	295	0	0	0	320	0	1 525
Mauritania	0	0	0	0	0	90	260	107	80	0	64	224	0	825
Mauritius	0	100	158	35	105	70	105	35	32	32	35	32	37	776
Mozambique	0	0	0	0	0	0	0	0	0	848	1 824	1 968	375	5 015
Niger	0	0	0	0	0	0	0	0	0	675	0	0	0	675
Nigeria	0	0	0	0	0	0	2 010	0	0	0	0	0	0	2 010
Rwanda	0	0	1 050	500	0	112	205	280	204	211	198	536	0	3 296
Sao Tome and Principe	0	0	0	0	0	0	0	0	0	20	0	6	20	46
Sierra Leone	550	250	0	0	0	0	0	0	0	0	0	60	0	860
Somalia	66	30	35	370	105	623	624	650	608	1 151	3 904	1 524	0	9 690
Sudan	2 010	3 658	2 490	3 500	244	1 990	1 485	490	512	256	640	416	542	18 233
Swaziland	0	0	0	0	0	0	80	47	0	100	69	64	64	424
Togo	0	0	0	0	0	0	125	0	0	0	0	0	0	125
Tunisia	0	0	0	210	1 085	560	1 110	600	256	0	0	0	0	3 821
Uganda	0	800	1 100	2 850	1 000	495	500	510	501	263	240	256	0	8 515
United Republic of Tanzania	1 014	0	2 500	2 000	1 990	968	820	1 984	1 017	550	2 074	512	0	15 429
Upper Volta (Burkina Faso)	0	0	0	0	0	0	0	0	0	0	1 607	312	10	1 929
Zaire	2 000	3 500	3 285	6 259	10 945	2 000	2 985	2 000	1 000	2 024	1 726	2 024	1 055	40 803
Zambia	610	1 800	1 208	1 398	2 061	1 820	1 700	1 842	1 078	2 000	1 284	1 408	180	18 389
Americas														
Brazil	0	0	0	1 255	0	0	0	0	0	0	0	0	0	1 255
Honduras	200	0	0	0	0	0	0	0	0	0	0	0	0	200

Asia														
Abu Dhabi[b]	0	0	0	0	35	15	0	0	0	0	0	0	0	50
Afghanistan	698	0	0	0	0	515	0	0	0	192	224	0	0	1 629
Bahrain	0	0	0	0	70	55	0	0	0	0	0	0	0	125
Bangladesh	0	0	300	0	0	948	4 783	11 331	19 026	0	0	0	0	36 388
Burma	1 500	1 500	76	0	0	0	0	0	0	0	0	0	0	3 076
Democratic Kampuchea	0	1 200	0	0	0	0	0	0	0	0	0	0	0	1 200
Democratic Yemen	0	150	35	0	350	0	220	602	0	300	0	96	62	1 815
Dubai[b]	100	0	0	0	35	105	0	0	0	0	0	0	0	240
India	1 000	0	0	0	0	0	0	1 606	0	0	0	0	0	2 606
Indonesia	1 000	2 350	450	300	0	0	0	0	0	0	0	0	0	4 100
Iran	0	0	0	0	2 026	11 096	0	0	0	0	0	0	0	13 122
Iraq	0	0	0	0	0	5 080	0	0	0	0	0	0	494	5 574
Kuwait	140	0	0	0	0	0	0	0	0	0	0	0	0	140
Lao People's Democratic Republic	100	900	0	500	1 025	0	0	10	0	0	0	0	0	2 535
Lebanon	1 000	1 000	0	283	2 006	1 388	250	502	0	10	65	60	0	6 564
Maldives	0	0	0	70	0	0	0	0	0	0	0	0	0	70
Mongolia	0	0	0	0	210	0	125	125	96	128	0	256	120	1 060
Nepal	450	2 900	2 915	700	1 995	5 875	3 340	2 800	0	1 024	2 048	1 024	0	25 071
Oman	0	0	0	0	454	0	65	0	0	0	0	0	95	614
Pakistan	0	420	4 298	9 005	11 930	3 495	9 085	14 245	7 524	5 000	2 016	1 500	1 000	69 518
Saudi Arabia	0	0	0	287	414	0	0	0	0	0	0	0	0	701
Sri Lanka	0	0	0	0	0	955	65	467	0	0	0	0	0	1 487
Syrian Arab Republic	0	0	0	0	0	1 010	0	0	0	0	0	0	0	1 010
UNRWA	0	0	87	210	0	173	0	171	73	82	163	100	109	1 168
Viet Nam	0	0	67	0	0	0	0	0	0	0	0	0	0	67
Yemen	250	0	315	245	735	210	245	145	450	0	252	100	64	3 011
Europe														
Cyprus	5	0	0	0	0	0	0	9	27	0	0	0	0	41
Yugoslavia	0	0	0	0	0	500	0	0	0	0	0	0	0	500
WHO HQ Miscellaneous	15	50	0	0	0	48	66	0	0	0	0	0	8	187
Oceania														
New Hebrides (Vanuatu)	0	0	0	0	0	0	0	0	0	3	0	0	0	3
Total	14 807	21 316	20 686	32 234	44 741	44 593	34 676	44 802	36 310	21 822	23 657	16 308	4 940	360 892

[a] From 1968 onwards, bifurcated needles started to be used for vaccination, enabling 1 dose to be used for the vaccination of 4 people. Hence numbers of doses are not necessarily the same as numbers of vaccinations performed. In addition, wastage of vaccine in the field must be taken into account. It can safely be assumed that the number of doses should be multiplied by 2 to give the number of vaccinations. Supply of vaccine by WHO was discontinued after 1980 when the eradication of smallpox was confirmed by the World Health Assembly.

[b] Now part of the United Arab Emirates.

therefore decided to request that all vaccine, after testing, should be shipped to Geneva for storage in refrigerated facilities leased by WHO. With this vaccine reserve, WHO administrative staff were able to send out vaccine within 48–72 hours of receiving a request.

During 1967–1979, more than 360 million doses of vaccine were distributed to some 70 countries or organizations (Table 10.9), both vaccine and bifurcated needles being made available to all developing countries that requested them whether or not they were conducting a special eradication programme. Between 1967 and 1969, 15–20 million doses were distributed annually, a figure which increased to 30–45 million doses during the period 1970–1975. Until 1973, however, the balance between demand and available contributions remained a precarious one (Fig. 10.3). Nevertheless, no programme was suspended for lack of vaccine although, in some countries and during some periods, vaccine reserves provided enough for only 1–2 weeks of continuing operations.

Success in ensuring an adequate supply of vaccine must be attributed, in part, to the use of the bifurcated needle from 1968 onwards. Most of the vaccine was supplied in containers which provided 0.20–0.25 ml, sufficient to vaccinate 20–25 persons by conventional scarification methods and 4–5 times that number with the bifurcated needle. For purposes of record-keeping, however, each vial continued to be regarded as containing 20–25 doses. For technical reasons vaccine could not be packaged in vials containing smaller quantities than 0.20–0.25 ml; had it been possible to do so, wastage would have been reduced, since the prescribed practice was to discard any reconstituted vaccine that remained at the end of the day.

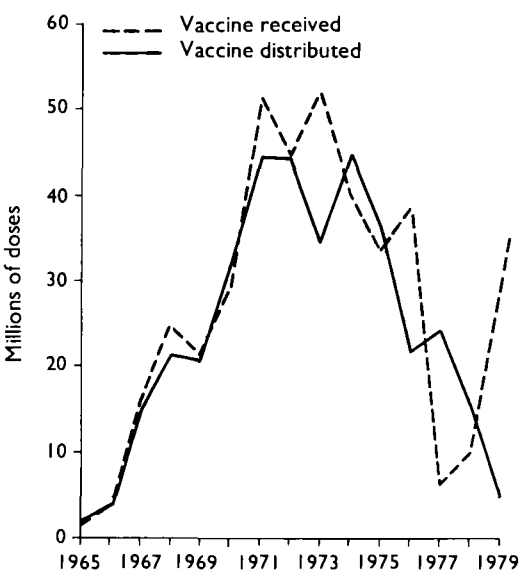

Fig. 10.3. Donations of smallpox vaccine to WHO: numbers of doses received and distributed, by year, 1965–1979.

The vaccine supply depot in Geneva proved invaluable and most vaccine was dispatched from it. In the interests of economy, however, some donated vaccine was sent direct from the producer to recipient countries. When Kenya began to produce more vaccine than it required, stocks were shipped direct from its laboratory to neighbouring countries; Iran's contributions were shipped to Pakistan; South American countries sent vaccine to one another; and Indian bilateral contributions were shipped direct to Bangladesh, Nepal and Sri Lanka in 1975–1976. Several regional offices proposed that regional depots should be established, but the small reserves available made this impracticable. When, in 1976, vaccine reserves at last began to accumulate, a second depot was created in New Delhi at the Regional Office for South-East Asia. Unfortunately, mechanical problems with the refrigeration units and frequent interruptions in the electricity supply made it necessary to close this depot down, and the international reserve of vaccine was subsequently stored by WHO in two locations in Switzerland—Geneva and Lausanne.

Development of Vaccination Devices

New vaccination devices used less vaccine than, and eventually replaced, the traditional scarification instruments used before 1967. Smallpox vaccination with jet injectors, first tested in a pilot project in 1965, was rapid and required only one-third as much vaccine as conventional methods. Jet injectors were widely used in three of the initial major campaigns—in Brazil (see Chapter 12), in western and central Africa (see Chapter 17) and in Zaire (see Chapter 18). However, they were little used elsewhere, partly because of the difficulty of maintaining and repairing them but mainly because the simple, effective and cheap bifurcated needle became available

in 1968, only a year after the Intensified Programme began.

The historical development of the bifurcated needle is described in Chapter 11, in which the needle itself and the containers used for sterilizing needles before use are illustrated (see Plate 11.15). Introduced in 1968 for use with a multiple-puncture technique devised by Henderson and Arita, bifurcated needles had replaced traditional methods in most countries by the end of 1968 and were in use everywhere by 1970. They cost only US$5 per 1000 and could be reused repeatedly after sterilization. Besides conserving vaccine, they were so simple to use that a local villager could be trained in only 10–15 minutes to reconstitute vaccine and to perform effective vaccinations.

Vaccine Practices and Complications

The WHO Handbook recommended that, in endemic and neighbouring countries, everyone, including infants, should be vaccinated. The only recognized contraindication to vaccination related to "individuals who were obviously severely acutely ill" and whose death, if it occurred, might be mistakenly attributed to vaccination. This recommendation was based on the rationale that in endemic areas the risks of complications following vaccination were far lower than those associated with contracting variola major or even variola minor. Moreover, it was recognized that most vaccinations would be performed by vaccinators who would be unable to identify conditions commonly accepted as contraindications to vaccination in non-endemic countries, such as immunological disorders, neoplastic disorders affecting the reticuloendothelial system, and treatment with corticosteroids, antimetabolic drugs or other chemotherapy.

The WHO Handbook described several possible vaccination techniques: multiple-pressure or scratch using a needle or rotary lancet, and the jet injector. An important change from conventional vaccination practice at the time was the recommendation that "the best skin preparation is none at all", and that "if the site is obviously caked with dirt, a cloth moistened with water may be used to wipe the site". This recommendation was based on a number of studies which had demonstrated that conventional methods for cleansing the skin with acetone or alcohol had little effect in reducing the number of bacteria but could destroy or partially destroy vaccinia virus if the vaccine was applied before the liquid had dried.

During the programme, few serious complications were observed which could be attributed to vaccination. The usual response to vaccination—a pustule, with sometimes a sore arm and fever—was readily tolerated although it caused some people to refuse vaccination—for example, agricultural workers during the harvest period. Disseminated vaccinia was observed in only a few patients. Cases of post-vaccinial encephalitis, a far more serious complication, undoubtedly occurred but because of the large number of prevalent illnesses which caused cerebral symptoms (e.g., malaria), it was difficult to know whether cases of encephalitis-like illness were complications of vaccination or were due to other causes. An unusual group of complications occurred in Ethiopia among nomads of the northern Ogaden desert, a number of whom, following primary vaccination, developed a deep, non-pustular crateriform lesion at the vaccination site which penetrated as deep as the muscle fascia. All those affected reported that they had applied the ashes of a thorny shrub to the lesion. Efforts to interest pharmacologists in this phenomenon were unsuccessful but the problem ceased when a sulfa powder was distributed and the nomads were advised to use this instead of the ashes.

SURVEILLANCE AND NOTIFICATION OF SMALLPOX CASES

Whereas, up to 1967, smallpox eradication programmes consisted entirely of mass vaccination campaigns, from 1967 onwards they also included surveillance. Little attention had been given to surveillance and the notification of smallpox cases either internationally or within countries up to that time; in the endemic countries, there were no nationally organized programmes designed to investigate and contain reported outbreaks. From 1967, however, the indicator used for measuring the progress of the programme ceased to be the total number of vaccinations and was replaced by the numbers of reported cases of smallpox and of endemic countries. Epidemiological analysis of the cases provided important information from the point

of view of the strategy and tactics to be employed and the allocation of resources.

The difficulty of explaining the concept of surveillance to programme staff and of gaining their acceptance of it was not appreciated, however, when the programme began. Mass vaccination campaigns were familiar and well understood but because they were complex to organize and execute, little time and few resources were usually available for surveillance. Incorporating into programmes what had seemed to be a simple, basic concept required much of the time and energy of the senior WHO smallpox eradication programme staff.

The Concept of Surveillance

The concept of a nationally supervised programme for reporting and investigating smallpox cases and containing outbreaks had, as its antecedent, the disease surveillance programmes of CDC in the USA (Langmuir, 1963). Dr Alexander Langmuir, its chief epidemiologist, had fostered the concept of surveillance since his appointment in 1949. He attributed the genesis of the concept to William Farr, who had been the superintendent of the Statistical Department of the Registrar General's Office of England and Wales in the 19th century. Farr's epidemiological analysis of cases and deaths over many years and by age group, area and season, made it possible to formulate hypotheses as to the way in which diseases were spread, which in turn suggested possible control measures and enabled forecasts of future trends in disease incidence to be made.

Dr Langmuir defined surveillance as the "continued watchfulness over the distribution and trends of incidence through systematic collection, consolidation and evaluation of morbidity and mortality reports and other relevant data". He pointed out that "intrinsic in the concept is the regular dissemination of the basic data and interpretations to all who have contributed and to all others who need to know". In developing surveillance in the USA, he focused primarily on diseases for which control measures were available, beginning with malaria, sylvatic plague and leprosy, and subsequently extended it to include diphtheria, poliomyelitis and other diseases. Working with state and local health officials, he and his staff obtained detailed information about reported cases, including confirmation of the diagnosis by laboratory study and basic data regarding age, sex, race and place of residence and, depending on the disease, information regarding vaccination status, possible place of exposure, etc. These data were regularly analysed, appropriate control measures recommended and surveillance reports prepared and widely distributed.

Henderson had worked with Dr Langmuir since 1955 and had served from 1961 to 1965 as chief of the Surveillance Section at CDC. It seemed to him only logical to endeavour to apply the principles of surveillance to the eradication of smallpox. This was stated in the Director-General's report to the Nineteenth World Health Assembly (World Health Organization, 1966b; see Chapter 9), which Henderson, as a consultant to WHO, had helped to prepare. This approach was strongly supported by Dr Raška, Director of the Division of Communicable Diseases, who had been a keen proponent of epidemiological surveillance while working in his own country, Czechoslovakia (Raška, 1964).

The concept of surveillance as applied to the smallpox programme was succinctly described in the WHO Handbook as follows:

> "The primary objective of the smallpox programme is the eradication of this disease. Surveillance is thus an essential component of the programme since the term 'eradication' implies that the number of indigenous cases of smallpox reach '0' ... Surveillance represents a great deal more than case reporting alone. It is composed of several components:
>
> (a) The routine, systematic collection of data, amplified appropriately by special field investigations and studies
> (b) The concurrent analysis and interpretation of reported data and studies
> (c) The initiation of appropriate definitive action including field investigation, epidemic control, modification of operational campaign procedures, recommendations regarding vaccination, etc.
> (d) Widespread dissemination of the compiled and interpreted data to principal reporting sources and to others concerned with disease control activities."

The Routine Systematic Collection of Data

A reporting network which provided for the collection of epidemiological data regarding each case of smallpox was the foundation of the system. Its goal was to ensure that each week all known cases of smallpox would be

reported by the peripheral health units in each country, through intermediate administrative units, such as districts and provinces, to national and, ultimately, to international authorities. The concept was simple, but there were formidable problems at every level in perfecting such a system.

Although this section deals primarily with surveillance at the international level, certain features and problems of national data collection systems need to be described in order to appreciate the quality of the data being provided in 1967 to WHO by national authorities in the endemic countries.

Reported cases of smallpox, which would be routinely notified if the system were functioning properly, inevitably represented only a portion of all the cases which actually occurred. The basic network of reporting units—health clinics, hospitals and dispensaries—documented only those who presented themselves for treatment. Many patients had no access to health care or did not go to health care units for fear of unwanted forcible isolation in a hospital or because they knew that there was no effective treatment. They could be discovered through searches or by field investigations of known outbreaks, but few health services undertook such activities. Even where there was complete notification of all cases seen by health units, the data provided only an indication of trends in incidence and of the geographical dispersion of the disease.

In all endemic countries, the notification networks themselves were seriously deficient. Usually, health units were supposed to provide weekly or monthly summaries of the number of patients seen, but smallpox was often only one of 25–50 different diseases that they were expected to report. Poorly supervised, overworked health staff customarily devoted little time to the preparation of lengthy reports which rarely led to any action being taken. Some regularly submitted reports to higher authorities but many did so only occasionally. In intermediate administrative units—such as states or provinces—and at national level, data were usually received and tabulated, often after extended delays, by clerical personnel whose responsibility was limited to ensuring that the data were entered accurately. Little notice was taken of whether all units reported or when they did so, and because the data were rarely used in programme operations, there was little incentive to improve the system.

All countries were expected to send to WHO weekly reports of cases of the so-called quarantinable diseases (smallpox, cholera, plague, yellow fever and typhus), and to indicate the areas in which they had occurred. Such routine reporting had been the practice since the adoption of the International Sanitary Convention of 1926, when receipt and publication of the information was the responsibility of the Health Organisation of the League of Nations, a function assumed by WHO on its foundation.

In WHO, in 1967, the receipt and tabulation of data on the quarantinable diseases was the responsibility of the International Quarantine unit, which later became the Epidemiological Surveillance and Quarantine Unit and in 1971 was renamed the unit for the Epidemiological Surveillance of Communicable Diseases; for convenience, it is referred to below simply as the "WHO quarantine unit". Reports were received direct from the countries concerned rather than through the WHO regional offices, and indicated the number of reported cases in each administrative unit, or "local area" as it was called, such as a district or county. The reports also specified which of the local areas were newly infected and which could be declared free of the disease. Each week a lengthy list of the existing and newly infected local areas in each country was published in the *Weekly epidemiological record* for each of the quarantinable diseases. In theory, this enabled quarantine officers and others concerned to determine whether or not a traveller had been in an area in which one of the diseases was present and to take appropriate measures. In practice, most health authorities recognized that reporting everywhere was deficient and usually considered the whole of a country to be infected if infection was present in any of its local areas.

The WHO quarantine unit also tabulated the number of cases reported. The data so compiled were considered to be the provisional official totals of cases, pending later receipt of annual reports from national governments. Such annual reports, when compiled and published some 3–4 years later by the WHO Division of Health Statistics, constituted the final authoritative international record of disease incidence. No attempt was made to reconcile the data in the provisional reports with those in the annual reports, and national authorities were seldom questioned as to the accuracy of the information provided.

Changes in the International Data Collection System

The inadequacy of the routine data collection system for smallpox cases had been recognized in 1967 but not until much later did it become apparent just how inadequate it was. Smallpox eradication programme staff had assumed that, because smallpox was one of the principal diseases subject to international quarantine agreements and because most infected countries submitted weekly reports, albeit after long delays, it was one of the better-reported diseases. However, field investigations soon showed that not more than 1 case in 20 was being notified. Later, through facial pockmark surveys, it became apparent that probably not more than 1 case in 100 was being reported and, in some countries, such as Ethiopia, perhaps 1 in 1000. Despite the incompleteness of reporting, however, the notified data proved to be important from the beginning of the programme for decisions about priorities and resource allocations and for assessing progress; ultimately, they were essential in determining that transmission had been interrupted and in certifying that eradication had been achieved.

Efforts to improve the system began with the initiation of the Intensified Programme. Deficiencies became apparent almost immediately when WHO staff attached to national smallpox eradication programmes cited national data which differed from those reported to the WHO quarantine unit. When efforts were made to reconcile the two sets of figures, it was discovered that, in many ministries of health, there were two sets of data, one compiled by a statistical unit and one by smallpox eradication programme staff. The statistical unit's data were taken from routine reports submitted by states and provinces, while those of the smallpox eradication programme office were often revised to take into account additional cases discovered during field investigations, reports obtained by the staff from states or provinces which had failed to file reports with the statistical office, and information on reported cases which had been mistakenly diagnosed. It was usually of no importance to national eradication programme staff whether the statistical unit's data differed from theirs or not, since such differences had no bearing on their operations.

Through correspondence with the countries and discussions with the WHO quarantine unit, WHO smallpox eradication staff sought to obtain the most complete national data available. In some instances, it was possible to obtain revised national figures extending over many months or several years, which usually showed much larger numbers of cases than those reported by the national statistical unit. The WHO quarantine unit did not take cognizance of such information because its responsibility was to compile only the current data officially reported to WHO and to maintain the registry of local infected areas. For the first three years of the Intensified Programme, two sets of data were maintained at WHO on smallpox incidence during the current and immediately preceding years. Depending on the WHO publication, sometimes one and sometimes the other set of data was used, but smallpox surveillance reports always used Smallpox Eradication unit data. In 1969, it was agreed that the Smallpox Eradication unit would assume the responsibility for all current data on smallpox cases and infected local areas, a procedure which reduced confusion and conserved manpower.

Meanwhile, through personal contact, correspondence and the publication of summaries of the smallpox situation in the *Weekly epidemiological record*, governments were urged to report more promptly and gradually began to do so. However, even as late as May 1970, reports from 5 countries were more than 4 weeks overdue and not until 1972 were reports received promptly from all the states of India (see Chapter 15). By the end of 1972, however, few reports from countries were delayed by as much as 2 weeks.

In 1970, another question arose in WHO Headquarters regarding what should constitute the authoritative international record of smallpox incidence. In that year, staff in the Division of Health Statistics observed that the numbers of smallpox cases in governments' annual summaries of disease incidence (a third data set) did not always agree with the data compiled by the Smallpox Eradication unit. Upon investigation, it was found that the differences usually reflected the fact that two sets of data had been compiled nationally. In other instances, clerical errors had been made in the annual summaries submitted, sometimes resulting, for example, in smallpox cases being reported by countries remote from endemic areas and with no known importations. These errors were quickly corrected by the governments concerned when they were

Table 10.10. World total of smallpox cases as recorded in April 1967[a] and as revised in 1987

Date recorded or revised	1959	1960	1961	1962	1963	1964	1965	1966
April 1967[a]	81 444	60 956	85 594	82 413	99 599	49 956	64 321	65 512
1987 revision	96 571	67 127	90 588	98 759	133 791	77 295	112 228	92 650
Percentage increase	19	10	6	20	34	55	74	41

[a] Unpublished World Health Assembly document A20/P&B/7.

brought to their attention but such data had been accepted without question in previous years. Towards the end of 1970, it was decided that the data compiled by the Smallpox Eradication unit, based on what it considered to be the most accurate national data, should be used in WHO publications. Thus, what had once been three different sets of smallpox data in WHO became one.

The possible suppression of reports of smallpox cases by national authorities was a continuing concern, although it did not happen often. Such suppression was most marked in western Asian countries and resulted, in part, from the adverse consequences of reporting cholera cases during a recent pandemic. These reports had induced other governments to impose unwarranted barriers to trade and travel which had caused serious economic losses. Some feared that reports of smallpox might result in similar measures being taken and therefore suppressed them. Cases of smallpox, especially when they were numerous, were not easy to conceal, however, and WHO learnt about them from many sources, including embassies, travellers and persons working in international organizations. All rumours of outbreaks were followed up by WHO by telex and by correspondence and sometimes by personal visits. Even when it was certain that smallpox was present, publication of the information without official government approval was diplomatically impossible. The suppression of reports had 2 adverse consequences: it jeopardized the credibility of the programme and the eventual acceptance of global eradication; and it made it difficult for the countries concerned to mobilize health resources and community support in order to control the outbreaks. Although most health authorities eventually cooperated in reporting, 4 did not acknowledge the existence of cases until many months or years later, and 3 eventually experienced major epidemics. These are discussed in Chapter 22 (Somalia) and Chapter 23 (Iran, Iraq and the Syrian Arab Republic).

Throughout the programme, national totals of smallpox cases were corrected whenever better information became available so as to reflect more accurately the actual incidence. Data for 1967–1977 were most carefully scrutinized, but changes were also made in data for a number of years preceding 1967. For example, the data presented in this book show global totals for smallpox cases between 1959 and 1966 substantially greater than those in the report (prepared in April 1967) submitted by the Director-General to the Twentieth World Health Assembly. The totals for the years 1959–1962 are 6–20% greater and those for 1963–1966 are 34–74% greater (Table 10.10). The larger discrepancies after 1963 reflect the fact that smallpox eradication staff in most countries reviewed and revised national and state or provincial data only from 1963 or 1964 onwards.

International Surveillance Reports

A basic precept of surveillance is, as has already been quoted from the WHO Handbook, the "widespread dissemination of the compiled and interpreted data to principal reporting sources and to others concerned with disease control activities". Accordingly, the first of what were intended to be quarterly international surveillance reports was issued by the Smallpox Eradication unit as a mimeographed document in September 1967. It was sent to some 200 persons, principally WHO staff concerned with smallpox eradication and national programme directors. A second report was issued in December 1967 and a third prepared in March 1968. Distribution of the third report was stopped, however, by senior WHO management staff, who believed that there were too many WHO reports and therefore decided to suspend most of them pending a

full review of WHO's publication policies. Eventually, it was decided that smallpox surveillance reports should be discontinued.

The coordination of a global programme was difficult enough, but without some mechanism for disseminating information on its status and the progress being made, the task appeared impossible. The matter was discussed in WHO in a series of difficult meetings extending over 8 weeks, and it was finally decided that a brief report on smallpox could be inserted periodically into the *Weekly epidemiological record*. From May 1968 onwards, such reports were published every 2–3 weeks.

Use of the *Weekly epidemiological record* had both advantages and disadvantages. The main advantage was that it was a well-established periodical with a circulation of some 5000 copies which reached a far larger audience than was possible with the mimeographed report. The disadvantage was that it published only epidemiological data, to the exclusion of other information which the smallpox eradication programme needed to have disseminated, such as the results of tests on the bifurcated needle and techniques for its use, and reports of the deliberations of relevant expert committees and scientific groups. Moreover, the periodical was normally sent by surface mail and not all WHO and national smallpox eradication programme staff had access to it. To solve these problems, it was agreed that additional copies of the smallpox surveillance section of the *Weekly epidemiological record* would be printed and sent by air mail, together with other special reports dealing with smallpox, to the 150–200 persons concerned with the programme. Thus began the practice of a special mailing every 2–3 weeks to all WHO and senior national smallpox eradication programme staff, a practice which ensured more rapid delivery than the traditional channels of communication through the regional offices. The WHO/SE, SE and SME series of documents listed with the references at the end of this book constituted most of the papers so distributed. Accounts by field staff were seldom prepared without considerable persuasion because, for many, English was not their mother tongue and few were experienced in writing papers for publication. A promise that smallpox eradication programme staff would edit all suitable papers increased the number submitted. Although the editorial burden was staggering, the papers proved invaluable in documenting useful observations made in the course of the programme and in fostering evolutionary change.

Following the incorporation of the smallpox surveillance reports into the *Weekly epidemiological record*, its editor, Dr Ian Carter, began to transform the publication itself. Once unkindly referred to as "the laundry list of infected local areas", the periodical gradually became a substantive document dealing with many diseases and reaching an increasingly wider public. With time, the smallpox surveillance reports gradually increased in length and frequently appeared on the first page, but the prominence given to smallpox eradication troubled the responsible Assistant Director-General, who felt that other important disease problems were not receiving sufficient attention. He therefore directed that the smallpox reports should be relegated more often to the inside pages. Thereafter, by tacit agreement, the smallpox surveillance report appeared on the front page of the *Weekly epidemiological record* only twice a year, when the semi-annual summaries were published.

RESEARCH

In 1967, few administrators or scientists believed that additional research was needed or would contribute to the achievement of smallpox eradication. This was understandable. A smallpox vaccine had been available and in use for more than 150 years and the commercial production of a thermostable vaccine had been perfected. The epidemiology of the disease under many different circumstances and in many countries had been described and the feasibility of eradication had been demonstrated in a number of developing countries. The basic task, as most saw it, was administrative—primarily that of organizing programmes to deliver vaccine to the population of the endemic countries. The attitude towards research was similar to that which had prevailed when global malaria eradication began in 1955. In that programme, research had been largely abandoned until 10 years later, when, with the programme progressing poorly, it was recognized that additional tools and different strategies were required. By then, however, competent and experienced research staff had turned to other fields. It was an important

lesson, and one which those in the Smallpox Eradication unit believed should be heeded.

In 1967, little smallpox research was in progress, and only US$20 000 were allocated in the WHO budget for the support of such research. With so few resources and with only 4 medical officers in the Smallpox Eradication unit in Geneva, WHO could not undertake a comprehensive, well-organized research programme. However, it was hoped that field staff might be able to make significant contributions and, to stimulate their interest, some 20 areas requiring research were identified in the WHO Handbook. In consequence, many field staff undertook and participated in a wide range of important studies from the beginning of the programme.

One research area was of paramount importance—to establish with certainty whether there was any natural reservoir of variola virus. Since yellow fever eradication had been thwarted by the unexpected discovery of an animal reservoir, and in the light of the suggestions then being made that there might be a simian reservoir of malaria, the question naturally arose whether there might also be an unrecognized natural reservoir of smallpox. This question was dealt with in a series of planned studies involving many different investigators and laboratories.

Substantial amounts were eventually spent in support of research by many laboratories and, although no quantitative data are available, they were far greater than the sums provided by WHO. Of especial note are the contributions of CDC in Atlanta, the Moscow Research Institute for Viral Preparations, the National Institute of Health in Japan, the Department of Virology of St Mary's Hospital Medical School in London, the National Institute of Public Health in the Netherlands, Wyeth Laboratories in the USA, the Calcutta Institute of Tropical Medicine in India, the Public Health Institute in Bangladesh, the Pakistan Medical Research Centre in Lahore and the University of Maryland School of Medicine in Baltimore, whose scientists worked in Pakistan.

In retrospect, it is unlikely that the global eradication of smallpox would have been achieved without the broader understanding of smallpox, its virology and epidemiology, which the research conducted after 1967 provided. The results of such research include: the redefinition of the epidemiology of smallpox and because of this, a change in the strategy so as to place increased emphasis on surveillance and containment; an improved understanding of the efficacy and duration of vaccinial immunity and, as a result, changes in practices pertaining to revaccination; a great improvement in vaccine production and testing procedures; the development of a new technique of vaccination, employing a new instrument; the genetic mapping of variola and vaccinia viruses to provide new insights into the relationships of the orthopoxviruses; the discovery and characterization of human monkeypox; and the development of sample survey techniques.

The research programmes and the observations made are described in detail in the appropriate chapters of this book. For this reason, only the highlights of some of them are described here so as to place them in the context of the development of the global programme.

A Natural Reservoir of Smallpox

From 1967 onwards, attention was focused on determining whether smallpox virus could persist in nature outside the human being. If smallpox were found to persist in an enzootic state, or if there were a closely related animal orthopoxvirus which could infect humans and whose transmission could be sustained in man, it was unlikely that smallpox could be eradicated. No less important was the question of how long variola virus could persist in nature, since this, too, had implications for the possible recurrence and re-establishment of infection in areas in which transmission had been interrupted. These problems are discussed in Chapters 2, 29 and 30.

The first review of the available data dealing with a possible animal reservoir of variola virus was published by Arita & Henderson (1968). They reasoned that, if there were a natural reservoir of variola virus, non-human primates were important candidates. As is discussed in the paper, a few reports had suggested that smallpox outbreaks did occur naturally in primates, but most of them dated from the 19th century. In view of the extent of endemic smallpox in countries in which primates were found and the paucity of reports of possible outbreaks in the present century, it seemed unlikely that primates really were a reservoir, but confirmation was

required. Also of interest was the closely related monkeypox virus, first described by Magnus et al. (1959) after an outbreak among a colony of laboratory primates and subsequently reported in 3 other laboratories. No human infection had occurred, but because adults in close contact with the animals were few and probably well vaccinated, no conclusions could be drawn about the possible infectivity of the virus for man. To study the matter further, Arita, in 1967, conducted a survey of 26 biological institutions which handled large numbers of primates to ascertain whether other, unpublished, outbreaks had occurred, to discover the circumstances associated with such outbreaks and to find out whether there had also been human infections. Five other outbreaks among primates came to light but no human cases. Almost all the illnesses occurred in Asian species and were clinically similar to those observed when primates were experimentally infected with smallpox.

To consider the problem of monkeypox and to develop a research agenda, a meeting of investigators from 6 laboratories (the Informal Group on Monkeypox and Related Viruses) was convened by WHO in March 1969 in Moscow. Thereafter, the investigators met every 2 years to plan a wide range of studies on the experimental infections of primates and other mammals with variola and monkeypox viruses and serological surveys of primates in Africa and Malaysia. New impetus to the efforts was given by the discovery of the first human monkeypox cases in 1970, and the working group was expanded to include epidemiologists and mammalogists. Subsequently, special field surveys were initiated to define the problem; these continued up to 1986 (see Chapter 29). They provided important substantiating evidence that no mammalian reservoir of smallpox existed and that monkeypox, confined to villagers in the tropical rain forest, could not be maintained by person-to-person transmission.

A second problem was to determine whether variola virus could persist in nature on fomites such as cloth or as scabs, and cause infection in man many months or even years later. That this was a cause for concern had been suggested in studies by investigators in the Netherlands, who demonstrated the survival of variola virus in scabs for as long as 13 years (Wolff & Croon, 1968). Whether the virus was of sufficiently high titre or in a form such that man could be infected was unknown. The possible persistence of variola virus in nature was also suggested by anecdotal accounts, dating from previous centuries, of cases and outbreaks following the exhumation of the body of a person who had died of smallpox and of cases said to have occurred in newly reoccupied houses in which a smallpox patient had died months or years before. The validity of these observations was uncertain because all had been reported from areas in which smallpox was then widely endemic. Also of concern were variolators in Africa and Asia, who were known to collect and retain scabs and pustular material for periods of a year or more.

To determine the possible risk of the persistence of viable variola virus under field conditions required many different epidemiological and laboratory studies. Laboratories in Bangladesh and India undertook to determine the duration of the viability of variola virus under different conditions of temperature and humidity. Epidemiologists were instructed to document with care the source of infection of cases, especially those in which there was a possibility of exposure to virus which had persisted in the environment. Special efforts were made to determine the source of infection of outbreaks in all countries thought to be free of smallpox. Variolators were contacted and questioned in detail about their experiences in retaining smallpox material, and variolation material was obtained from them for titration in the laboratory. The results of these studies are described in Chapters 2 and 30. Ultimately, it became clear that, even under favourable conditions of low temperature and humidity, the virus did not survive for more than a few days or weeks in a form which could induce infection, unless inoculated, as in variolation. Even in this case, variolators reported that they had difficulty in inducing infection with material retained for longer than a year.

Epidemiological Observations

Of the many epidemiological observations, the most important were those which indicated that surveillance and containment should be accorded a much higher priority than had initially been appreciated. The first and most comprehensive of the field studies were those conducted in Pakistan and Bangladesh (then East Pakistan) during 1965–1968

and directed by scientists from the University of Maryland, USA, and the Pakistan Medical Research Council (see Chapters 4 and 14). In careful studies of the characteristics of the spread of smallpox, they showed that, even in highly infected areas, cases tended to occur in clusters rather than being widely disseminated, and that the disease spread less rapidly and less easily than was commonly believed and only through close personal contact. Moreover, during periods of seasonally low transmission, they found few continuing chains of smallpox transmission, mainly in urban areas. These characteristics suggested that the spread of smallpox could be more rapidly interrupted if greater emphasis were placed on the discovery of cases and the containment of outbreaks, especially during the season when transmission was at a low level and in urban areas. Observations in eastern Nigeria in 1967, in India in 1968, and in Brazil and Indonesia in 1969 confirmed the practicability of this approach. These observations were made known to all smallpox eradication programme field staff, but the basic concepts of surveillance and containment were slow to be accepted, having to be rediscovered and/or demonstrated in special programmes in most areas before they were incorporated into programmes.

Many other studies and observations arising from field programmes led to changes in strategy and operations (see Chapters 4 and 12–22). Among these were studies which showed that variola minor could persist for long periods among small nomadic groups, necessitating special surveillance procedures; that women in Afghanistan, confined to their houses by the practice of purdah, were mostly immune owing to a previous attack of the disease or to vaccination and that special vaccination programmes for them were unnecessary; and that the airborne transmission of variola virus over a distance was possible but only under exceptional circumstances and within buildings and so was not of concern. Methods were developed by which to estimate the incidence of smallpox in previous years, and special studies documented the frequency of persistence of facial pockmarks, observations which were important in deciding on the strategy for certification.

Few investigations were undertaken which required substantial laboratory support, partly because many of the studies required no more than physical observations of lesions or scars, and partly because few laboratories were equipped to process large numbers of specimens. Studies which did involve laboratory support were conducted in Bangladesh, India, Somalia and Zaire and concerned the behaviour of other animal poxviruses (see Chapter 29) and the pharyngeal excretion of variola virus among contacts of patients (see Chapter 4).

Vaccination Practices

Through research, not only did better vaccination instruments come into universal use but other vaccination practices also changed. Policies with regard to the youngest age for vaccination and the recommended frequency of revaccinations were changed. In most endemic countries, in 1967, primary vaccination was not given until the child had reached 3–12 months of age, and revaccination was performed every 3–5 years. The vaccination of neonates, however, had long been known to be a safe and effective practice and, in fact, had become a standard procedure in some countries of eastern Asia (Urner, 1927; Moodie & Cheng, 1962). Dr A. R. Rao's confirmation of these observations, in a WHO-supported programme in southern India, served to encourage wider acceptance of the practice, which made it easier to achieve higher levels of vaccination coverage during mass vaccination campaigns and enabled very young children to be protected during outbreak containment. That immunity following vaccination might be far more long-lasting than had been thought was suggested by field observations which showed that, even in well-vaccinated populations, 80–95% of cases occurred among those who had never been vaccinated. More precise measurements of vaccine efficacy subsequently confirmed that high levels of immunity continued for at least 10–20 years. These findings, documented early in the programme, led to a shift in the emphasis of vaccination campaigns from an effort to reach the entire population to approaches which would ensure that everyone had received primary vaccination at some time.

Vaccine Production and Testing

In 1967, much was known about commercial methods for the production of freeze-dried smallpox vaccine and a production manual

was issued by WHO in 1968 (SE/68.3 Rev.2). Nevertheless, several studies were undertaken to examine certain aspects of the process, such as the optimum day for harvest to ensure maximum virus yield, the yields of virus produced by different strains, and alternative methods of purifying the vaccine and reducing bacterial content (see Chapter 11). Testing procedures were thought to have been standardized, but when different laboratories obtained quite different results on testing the same batches of vaccine, studies showed that slight but previously acceptable variations in technique were responsible; these were corrected. Although collaboration among potentially competing production laboratories is uncommon, this was not the case in the smallpox eradication programme. Laboratories in Canada, Czechoslovakia, the Netherlands, the USSR and the USA cooperated and shared information in solving problems, and their findings were communicated to all production laboratories.

Characterization of the Orthopoxviruses

An examination of the similarities and differences between variola virus and other orthopoxviruses was important in assessing the likelihood that such a virus might, in some manner, mutate to a form whose virulence and transmissibility were such that infection could be sustained in man. Support for studies aimed at a more precise characterization of orthopoxviruses was provided by WHO to laboratories in London and Birmingham (England), Atlanta (USA), Tokyo (Japan) and Moscow (USSR), each of which committed substantial additional resources of its own. The importance of these studies increased with the discovery, in the early 1970s, in the Netherlands and in the USSR, of virus strains apparently isolated from animals and having characteristics indistinguishable from those of variola virus. Until the discovery of restriction endonucleases, which enabled the DNA structure of viral strains to be analysed, these analyses relied on biological markers, such as growth properties in different animals and cells and the optimum temperature for growth. The techniques were complex and time-consuming and the interpretation of the results was often uncertain. Ultimately, restriction endonuclease analyses of viral DNA proved of the greatest value. The isolates of variola-like viruses obtained from animals in the Netherlands and the USSR were eventually shown to have been laboratory contaminants (see Chapter 29) and genetic analysis showed that it was highly unlikely that any of the large number of animal orthopoxviruses could be transformed by one or even several mutational steps into a virus which resembled variola virus.

Summary

Even from this brief recapitulation, it is apparent that the epidemiological and laboratory research stimulated and coordinated by WHO contributed materially to the achievement of smallpox eradication. The effort was not, overall, a wholly integrated and comprehensively planned effort and was only modestly supported by WHO funds, but it was remarkably well directed towards finding solutions to operational questions and needs. Of signal importance was the ready cooperation of the investigators and their willingness to make available their papers and their data before publication. This, in turn, permitted the earliest possible application of new findings.

STRATEGIES AND TACTICS IN THE EXECUTION OF NATIONAL PROGRAMMES

Introduction

A survey of the approaches adopted in national vaccination campaigns and in surveillance and containment measures is provided in this section as an introduction to Chapters 12–22, which describe field operations in the various countries. The principles and practices were common to most but many aspects of the structure and method of operation of each national programme were unique, since each had to be adapted to the prevailing administrative, social, demographic and geographical conditions and each changed with time in response to experience and needs.

As has previously been described, the basic strategy for national programmes called for 2 different activities: (1) mass vaccination campaigns, assessed for both coverage and take rates by special teams; and (2) surveillance and containment of outbreaks. As infor-

mation accumulated on the extent of vaccinial immunity and the epidemiology of smallpox in the different countries, it became apparent that mass vaccination campaigns, particularly in Asia, were less important than the discovery and containment of outbreaks. Vaccinial immunity was found to be generally higher in most countries than had been expected and, in some countries, smallpox cases were so few that a comparatively simple surveillance and containment programme could serve to interrupt transmission.

Because mass vaccination campaigns were the traditional control method and were most readily accepted by national authorities, all endemic countries and many of those adjacent to them conducted such campaigns. While perhaps unnecessary in some areas, they served an important additional function in that vaccination teams, moving from village to village, were able to detect unreported cases of smallpox or to confirm its absence.

Surveillance–containment programmes, however, were frequently slow to begin, because the logistics of mass vaccination campaigns were so demanding and the techniques unfamiliar. Some programmes, adopting the tactics used for malaria eradication, deliberately delayed the commencement of surveillance until mass vaccination had been completed, an activity which they equated with the "attack phase" of the malaria programme. It was not always easy to persuade national programme staff and WHO smallpox eradication advisers that surveillance–containment operations should begin immediately and be accorded as high a priority as mass vaccination.

The importance of surveillance and containment was emphasized in discussions at the World Health Assembly and by Health Assembly resolutions in 1968 and 1969, and again by an explicit resolution of the Executive Board (EB45.R20), subsequently endorsed by the Twenty-third World Health Assembly (1970), in which the Board requested "all countries to take appropriate steps to improve further case-reporting and to adopt as an objective the immediate investigation and containment of all reported cases and outbreaks of smallpox from 1970 onwards" (World Health Organization, 1973a). Much effort was devoted to accomplishing this objective and demonstration-type programmes were organized to encourage it. Its importance was further reinforced in numerous publications and communications. From 1969 onwards, smallpox eradication staff at WHO Headquarters recommended that surveillance–containment measures should be given priority over mass vaccination but because change was slow to come, they proposed in 1972 that all resources should be directed to surveillance–containment and that mass vaccination should be stopped. Although this proposal did not reduce the interest in mass vaccination on the part of most national authorities, it ultimately served to focus sufficient attention on surveillance and containment to permit the development of satisfactory programmes. To suggest that mass vaccination was unnecessary in any circumstances was recognized to be extreme and simplistic but it seemed necessary to do so at the time in order to alter national strategies. This was not without certain repercussions, however. By the time the emergency programme was introduced in Somalia in 1977, the principle of surveillance–containment had acquired a doctrinal quality and some WHO smallpox eradication advisers argued that it was heretical to conduct mass vaccination campaigns in any area, whatever the need (see Chapter 22).

The most important factors determining the success of all programmes were the quality of senior staff at the national level and their willingness to go into the field to see for themselves what progress was being made, to find solutions to problems and, by their example, to encourage lower-level supervisors to do likewise. In most countries, it was both traditional and accepted for supervisors, even at the lowest administrative levels, to remain in their offices. Many considered it demeaning to leave them, and those who wished to do so frequently lacked the necessary authority or transport. Supervision was customarily provided through verbal orders and written directives, and the results of programmes were assessed, if at all, through written reports, often of dubious veracity. In the smallpox eradication programmes, the supervisors were provided with transport, and WHO staff and consultants, by their example, played an important role in helping to change traditional patterns. Frequently, it was found that national and WHO smallpox eradication programme supervisors were almost the only supervisory staff to visit health programmes in the field or district centres and dispensaries. This type of frequent contact between supervisors and field personnel not only served to

resolve problems more rapidly and to redirect activities more efficiently but also proved invaluable in sustaining morale and interest.

In the following pages, the general practices followed in mass vaccination campaigns are discussed first, followed by those in the surveillance–containment programmes.

Mass Vaccination Campaigns

Objectives

Before 1967, the smallpox eradication strategy relied entirely on mass vaccination in the belief that, when the proportion of susceptible persons in the population had been substantially reduced, transmission would cease. Until 1964, it had been assumed that this would occur when 80% of the population had been successfully vaccinated within a period of 4–5 years (World Health Organization, 1959b), an arbitrary figure with no scientific basis. Between 1959 and 1966, mass vaccination campaigns succeeded in eliminating smallpox in a number of countries, but whether 80% of the population had been successfully vaccinated is unknown as little attempt was made to assess the results of the campaigns and knowledge of the numbers of vaccinations performed is of little value because most of the vaccine used was thermolabile and lacked potency, so that many vaccinations were undoubtedly unsuccessful.

The WHO Expert Committee on Smallpox (1964) declared the figure of 80% to be insufficient and recommended that the goal should be to vaccinate 100% of the population. The only basis for this recommendation was the observation in India that smallpox persisted in some areas despite vaccinations which, in the numbers reported, were equivalent to 80% or more of the population. The Committee, however, ignored the information from field studies in India itself (later critically examined by Gelfand, 1966), which showed that the proportion *successfully* vaccinated fell far short of 80% because of the use of subpotent vaccines and the frequent revaccination of the most easily accessible groups. The proposition that smallpox could be eliminated by successfully vaccinating 80% of the population was thus discarded but on scientific evidence just as inadequate as that on which it had originally been based.

The WHO Handbook also recommended that mass vaccination campaigns should aim at successfully vaccinating 80% of the population. The figure was an arbitrary one, intended only to indicate what could reasonably be expected in a well-conducted programme.

One can only speculate as to how many countries might have succeeded in interrupting transmission simply with an effective mass vaccination campaign reaching 80% or more of the population. However, from the authors' review of programmes conducted after 1967, it would appear that mass vaccination alone resulted, or probably would have resulted, in the elimination of smallpox in South America and most African countries but not in the densely populated countries of Bangladesh, India, Indonesia and Pakistan. Even in America and Africa, however, surveillance programmes were necessary, to provide the basis on which to be able to certify that transmission had been interrupted.

Administration

The mass vaccination campaigns were conducted by national health staff, usually with technical advice and material assistance from WHO and other agencies. A full-time programme director and unit were usually made responsible for the programme; in the larger countries, special units were also created at state or provincial levels. The programme staff were an integral part of the health ministry and worked with existing health service units, coordinating their activities whenever possible with those of other special programmes, such as those for BCG vaccination, malaria eradication and leprosy and yaws control. Their salaries were paid by the respective governments, although in some cases WHO supplemented the salaries of some senior staff to enable them to work full time in the programme. In most countries, international assistance bore the costs of all supplies and equipment as well as living allowances and travel costs for surveillance teams and the costs of petrol and vehicle repairs. After 1973, when many temporary workers began to be employed to intensify programmes in the remaining endemic countries of Asia and eastern Africa, their salaries were also met by funds from international assistance.

Preparations

The necessary preparations for a vaccination campaign could be completed within a matter

of a few weeks or a month or two, but most programmes did not begin until 6–18 months after an agreement had been signed between the government concerned and WHO. The length of the delay was usually determined by the time required to deliver the necessary vehicles, but also sometimes by a lag in the allocation of government funds for salaries. During this period, information regarding the past history of smallpox in the country was obtained, demographic data and maps were collected, and staff were selected and trained. As has already been noted, the compilation of the smallpox data available from state and provincial offices and other sources often revealed more cases than those recorded in statistical offices and officially reported to WHO. The compilation of such data made better baseline information available for use in deciding on priority areas for vaccination and in gauging subsequent progress. Except in areas in which malaria eradication programmes had been conducted, the existing maps were generally inaccurate and demographic data often at considerable variance with what programme operations later revealed. Nevertheless, such maps and data were useful as points of departure, changes being made in them as the programme progressed and additional information was obtained.

The supervisors and vaccinators for the programme were mainly health personnel who had previously been engaged in smallpox vaccination or who had been transferred from other field programmes, such as those for BCG vaccination or leprosy or yaws control, which for one reason or another had all but ceased operations. The numbers of health personnel required for the programme were not large and, because underutilization of health personnel in most endemic countries was common, it was seldom necessary for the government to hire additional staff to serve as vaccinators or supervisors. Those who served as vaccinators had usually had at least 6–8 years of education and were sufficiently literate to use forms for recording data. Illiterate vaccinators were also successfully used, especially after 1973, when the programmes were greatly intensified. Supervisors, in general, had had at least 10–12 years of education and had sometimes received additional training in the operation of health programmes.

For most smallpox eradication programmes, special training lasting 1–4 weeks served to familiarize the staff with the nature of the programme and with their duties and responsibilities. In all but the largest countries staff numbers were sufficiently small to permit close and continuous contact between the senior national staff, the field supervisors and the vaccinators, thus facilitating supervision and a progressive improvement in performance. In larger programmes, and where the staff were widely dispersed, supervision was more difficult and the programmes were generally less effective. During the course of the programme in India over the period 1974–1977, however, an effective method was found for the supervision of large numbers of widely dispersed staff (Brilliant, 1985). A 1-day meeting of senior staff and supervisors was held every month to review performance, progress, strategy and problems. Subsequently, the supervisors and junior supervisors held a similar 1-day meeting and, finally, junior supervisors and vaccinators reviewed the progress in an area served by a health centre. Although the national programme involved more than 100 000 workers, it proved feasible to supervise activities closely and to modify and continually redirect the programme effectively.

Special activities were undertaken to interest and involve health staff based in the outpatient departments of hospitals, in health centres and in similar facilities. In group meetings and during field travel, smallpox eradication programme staff regularly discussed with them the nature and objectives of the programme, emphasized the need to report smallpox cases, and provided supplies and instruction in the proper storage and use of freeze-dried vaccine. Experience showed, however, that in most countries such health staff failed to report cases regularly, usually vaccinated very few of those who attended clinics and seldom undertook to vaccinate people living in nearby houses or villages.

Provision was made for the cold storage of vaccine (at 0–4°C) in the capital city, sometimes in refrigerators belonging to the programme and sometimes in other units used for the refrigeration of meat or vegetables and fruit. Vaccine was also kept at state and district centres in ordinary refrigerators, which were often provided by the programme, the number and location depending on the difficulties of travel and the availability of transport. The distribution system was designed so that vaccine would not be exposed to ambient temperatures for more

Plate 10.25. Refugee camp for Ethiopians in Djibouti. Special vaccination campaigns were regularly conducted in such camps to prevent outbreaks of smallpox.

than 30 days. In most programmes, however, the maintenance of an effective "cold chain" proved difficult and was often unsatisfactory, usually because of the mechanical failure of refrigerators, interruptions in electrical supply or lack of kerosene. Not infrequently, the vaccine was exposed to ambient temperatures for more than 30 days but because of the high titre and the stability of most vaccines, primary vaccinations were usually successful in 95% or more of the subjects concerned even when the vaccine had been exposed to such temperatures for as long as 6–9 months. Despite failures in the distribution system, unsuccessful vaccinations with properly manufactured vaccine were uncommon after 1967.

Special efforts were made to ensure that vaccination teams and health units always had on hand an adequate supply of vaccine and bifurcated needles. The instructions therefore called for orders to be submitted in advance so that supplies could be replenished well before they ran out, but the system rarely worked well; most units and many countries waited until supplies were exhausted before ordering more. The reserve supplies of vaccine and needles in Geneva, from which deliveries could be made within 48–72 hours, helped to overcome this difficulty.

Finally, health education materials, such as posters and brochures, radio messages and other media material, were prepared. Although these were used in all programmes, such studies as were done showed that individual discussions with villagers by team leaders, vaccinators or search workers were much more effective in obtaining cooperation and participation.

After the necessary equipment had been assembled and personnel recruited, pilot projects were conducted in most countries. Because mass vaccination was comparatively simple and often familiar, they seldom lasted more than a few weeks or months and were designed primarily for training purposes rather than to test alternative methodologies.

Execution of the mass campaigns

Most mass vaccination campaigns were designed to be completed during a period of 1–3 years, depending on the size of the country and the number of personnel available. Field activities usually began in areas with the greatest population density and the

highest smallpox prevalence, thereafter moving progressively to adjoining areas. In practice, it was found best to begin the campaign in an area in which vaccination was readily accepted by the population and the logistics were simplest, and to move to more difficult areas when operational systems were well established.

Most countries used mobile vaccination teams; they varied in size but usually consisted of 2–8 persons, each team being given a vehicle. For ease of supervision and supply and to economize in transport, groups of 4–8 teams usually worked in contiguous areas under the direction of a senior health supervisor. The teams usually worked without interruption for 3 weeks, followed by 7–10 days' rest. A useful tactic, but one seldom used, was for a team of 2–3 supervisors to move from area to area and to employ local health staff to assist them. Having individuals on the team who were familiar with the people and the area and who spoke the local language enabled better vaccination coverage to be achieved. Although wider use of this approach would have been desirable, the necessary cooperation of the local health staff was usually difficult to obtain.

If work continued throughout the year, 250 days of field work were possible, but 150–200 were more usual. In some Asian countries in particular, religious and national holidays were frequent and often prolonged; in others, effective field work during the seasonal rains or the hottest months was difficult, if not impossible.

Work schedules had to take a number of factors into account. Nomads, for example, were often widely dispersed during most of the year but would congregate at certain sites to graze their animals or to assist in the harvest during a comparatively brief period. In rural areas, farmers busy in the fields avoided vaccination for fear of the resulting fever and sore arm; better coverage was therefore achieved by vaccinating during slack periods in the agricultural calendar. Special programmes had to be scheduled to vaccinate people attending religious festivals, as in the Indian subcontinent and in many Muslim countries, where thousands or even millions of people often forgathered. Programmes for refugees and migrant seasonal workers were also important. The time of vaccination also had to be taken into account. If vaccination was offered, for example, from 9 o'clock in the morning to 5 o'clock in the afternoon, large numbers of persons were usually away from their villages—in the fields, at school or at markets. Vaccination in the early morning and in the evening resulted in better coverage but such a schedule was often difficult to arrange.

Two basic approaches to mass vaccination were employed. Throughout Africa and South America, the assembly-point system, in which many subjects for vaccination gathered at a designated site, was well accepted and therefore widely employed. In Asian countries, house-to-house visits were usually made by vaccinators, although large numbers of persons were sometimes vaccinated at places such as railway stations, ferry crossings and refugee camps.

Assembly-point vaccination. At an assembly point, many people could be vaccinated by a few vaccinators in a short time if the local leaders lent their support. That support was usually sought by an "advance man" attached to the mobile teams, who visited the area concerned one or more days before the team was to arrive in order to meet the leaders, explain the nature of the programme, and enlist their support in assembling the people and controlling the crowd.

Jet injectors had been expected to be of especial value in campaigns using the assembly-point method, but their potential was seldom realized. With very well organized assembly points 1000–1500 persons an hour could be vaccinated using a jet injector but it was difficult to assemble and to vaccinate so many persons for more than a few hours each day. Because the great majority of the population lived in small, widely scattered towns and villages, the travel of the teams and the preparations at each individual site took a good deal of time. In practice, a team of 2 vaccinators using jet injectors averaged only 1500–3000 vaccinations a day, much the same as the number performed by 3 vaccinators with the much simpler bifurcated needles. Thus, in most circumstances, bifurcated needles were preferred.

The assembly-point system was usually effective in obtaining coverage rates of 80% or more wherever local support was reasonably good and even higher rates when smallpox was known to be present in the area. In rural areas, the best coverage was obtained when the assembly points were so situated that no one had to walk more than 5 kilometres, and preferably no more than 2

Plate 10.26. An "advance man" meets with village elders in Ethiopia to demonstrate vaccination and to explain the programme.

kilometres. Otherwise, many individuals were missed, especially children who were too young to walk very far or too old to be carried over long distances. In cities and towns, assembly points were much more closely spaced.

At the assembly points, police or village leaders were needed for crowd control, especially in areas in which the people were not accustomed to orderly queuing. Special measures also had to be taken to prevent the crowds from pressing in around the vaccinators to watch what they were doing. This was usually effected by arranging for the line of people to be vaccinated to pass through a building or between specially erected fences. The information recorded about each person vaccinated was kept to a minimum. Although some health authorities insisted initially on registering each individual by name, age, sex and place of residence, they soon discovered that this made the clerical task too burdensome and that the records compiled were of little or no value subsequently. A simple vaccination tally sheet (Plate 10.27) was commonly used to record the number of vaccinations performed by age group.

House-to-house vaccination. In most of the endemic countries of Asia, vaccinators customarily went from house to house, and this practice was continued throughout the programme. To many health officials, systematic and orderly house-to-house visits seemed more likely to ensure high levels of vaccination coverage than asking people to gather at assembly points. The method, however, had certain intrinsic drawbacks which generally resulted in a lower rate of coverage. Since fewer persons could be vaccinated in a day than at an assembly point, larger numbers of vaccinators were required. They were often more poorly paid, less strongly motivated and therefore less reliable than the assembly-point vaccinators. They were also widely dispersed, so that it was difficult to supervise them, or even to determine whether they had worked at all. The household members, since they did not know when the vaccinators were going to call, were often absent, and resistance to vaccination was more frequent when families were approached one by one in this manner than when they were part of a large crowd in the carnival type of atmosphere associated with the assembly-point method. During the global eradication programme, well-supervised house-to-house programmes were conducted in some high-risk areas of Asian countries, but were seldom assessed. In most areas, traditional practices continued, indivi-

VACCINATION TALLY SHEET

Age Group	Primary Vaccinees	Age Group	Revaccinees
0-4	15 / 35	0-4	
5-14		5-14	
15+		15+	

TEAM NUMBER_____
PROVINCE_____
MED. DISTRICT_____
DATE _____
VACCINATION AREA_____
POPULATION ESTIMATE _____

SMALLPOX VACCINE

LOT NUMBER_____

PAGE SUMMARY

	Primary vaccinees	Revaccinees	TOTAL
0-4			
5-14			
15+			
TOTAL			

SIGNATURES: RECORDER TEAM LEADER

Note: 1. Boxes by age group are roughly proportionate to population distribution in most endemic areas
2. If sex is to be recorded instead of vaccination status, males may be recorded on the left and females on the right

Plate 10.27. A vaccination tally sheet.

dual vaccinators being assigned responsibility for populations ranging from 5000 to 20 000 but seldom vaccinating more than 25–50 persons a day. As is described in Chapter 15, the system was costly for what it achieved.

Smallpox vaccination was generally well accepted throughout the world, even among many groups with little prior contact with health services. Groups which resisted vaccination tended to make the greatest impression on programme staff and their importance was magnified by virtue of the time and energy needed to vaccinate them. The older adults, especially women, often objected to vaccination on the grounds that they were already immune, which, in fact, most were. However, for a team trying to contain an outbreak and therefore to vaccinate everyone in the area, the older women in particular were a continual source of frustration. Some orthodox religious groups objected to vaccination on principle; on several occasions this resulted in outbreaks difficult to control. However, the numbers involved were seldom large and, through religious leaders and government officials, most people could eventually be persuaded to accept vaccination. Where variolation was practised, as in the mountainous areas of Afghanistan and Pakistan and in Benin, Togo and western Nigeria, variolators, as well as some members of the population, objected to or actually forbade vaccination. Except in the more remote areas of Pakistan, however, it was eventually possible to persuade most of them to accept it.

The largest group to resist vaccination were the Amharas of the highland plateau area of Ethiopia. To most Amharas, vaccination was unknown and neither religious leaders nor government officials were able to influence their attitudes significantly. Because only the mild variola minor form of smallpox was prevalent in the area, they did not fear the disease, even when outbreaks occurred. Many methods were used to enhance their acceptance, including that of providing drugs against other diseases after successful vaccination, but large numbers of people still refused. Fortunately, resistance was by no means universal and smallpox transmission gradually ceased in this widely dispersed population.

The simultaneous administration of one or more antigens in addition to smallpox vaccine was known to be both safe and efficacious as well as economical of transport and personnel. For this purpose, however, additional resources had to be made available for the programme and changes in operational procedures introduced. This proved possible in a number of control programmes. In

western and central Africa, measles vaccine was given to all children between 6 months and 4 years of age; in some programmes yellow fever vaccine was also given to persons of all ages; and in others, BCG vaccine was administered, usually to those aged 0–15 years. In many countries of eastern and southern Africa, both smallpox and BCG vaccines were given from the beginning of the programme and, in Afghanistan, diphtheria, pertussis and tetanus (DPT) vaccine and BCG vaccine began to be administered after smallpox transmission had been interrupted.

The question whether other vaccines might be given during the smallpox vaccination campaign did not arise in most countries, however. Up to the end of 1977, when the mass campaigns had concluded, few of the endemic countries routinely provided other vaccines because they lacked the foreign currency to buy them and little was contributed by international agencies. BCG vaccine, which UNICEF provided to a number of developing countries, was an exception. It was difficult, however, to conduct a programme for the administration of both BCG and smallpox vaccines, since the former was usually given by a more time-consuming method—intradermal injection using a syringe and needle. In Africa, vaccinators could routinely administer 500 or more smallpox vaccinations a day using bifurcated needles but only 100 or so BCG vaccinations. To give both vaccines together required either a substantial expansion in the size of the teams—difficult because of the limited transport available—or a much slower-paced programme and inevitably a delay in interrupting smallpox transmission.

To facilitate the development of combined smallpox–BCG vaccination programmes, the Smallpox Eradication unit in Geneva promoted studies of the feasibility of administering BCG vaccine with the bifurcated needle and with the jet injector. While the results obtained with the bifurcated needle were equivocal or poor, those with the jet injector were quite satisfactory. Where jet injectors were used—in Zaire and many countries of western and central Africa—the two vaccines were administered at the same time but inoculated into different arms. Except for the the constant difficulty of ensuring an adequate supply of BCG vaccine, these programmes generally functioned well.

Although an effective mass campaign for the simultaneous administration of different antigens was difficult to start, the feasibility increased as experience was gained and an administrative structure developed. It seemed logical and desirable to the WHO Smallpox Eradication unit to encourage the transformation of the programme, as smallpox began to be eliminated, into one for the provision of other antigens as well. DPT and poliomyelitis vaccines were the best candidates, as the diseases concerned posed problems in the developing countries and the vaccines were inexpensive and as yet little used. Donations of vaccine would, however, have been needed as well as additional staff at Headquarters to develop plans, mobilize resources and provide training. Efforts were made in 1970 and later to persuade senior WHO staff of the desirability of this approach, the importance of timely action increasing as one country after another became free of smallpox and began to dismantle its programme. There was, however, resistance to the development of what was seen as yet another "vertical" programme until 1974, when the Twenty-sixth World Health Assembly decided to establish the Expanded Programme on Immunization. By then, smallpox eradication had proceeded so quickly that a number of national vaccination programmes had ceased to function.

On balance, the mass vaccination campaigns were remarkably successful in most countries, high levels of acceptance and coverage being attained in almost all in 3–4 years or less. The campaigns cost most countries no more than they had been spending on their regular control measures. As the chapters on field operations will show (Chapters 12–22), the assembly-point system of vaccination did not require large numbers of national personnel and international support usually amounted to no more than US$0.07–0.25 per head of population over the course of the programme. The mass campaigns were, moreover, politically attractive, in some areas providing an important link between the people and the government—sometimes virtually the only one.

Maintenance vaccination by the health services

At the conclusion of their mass vaccination campaigns, most countries planned for continuing programmes of maintenance vaccination to be provided by the existing health services. Health units were requested to ensure the vaccination of newborn infants

and of children at health clinics and at school entry and to undertake periodic community-wide vaccination campaigns, but the outcome was seldom satisfactory. In all countries, large numbers of people visited health units daily for treatment but the opportunity was rarely taken to vaccinate them. When health centres were inspected, vaccine was regularly found which had been reconstituted days or even weeks previously and continued in use even though stored without refrigeration. Many of the vaccinations performed were probably unsuccessful but in few centres were subjects checked to see what the results had been.

After the mass campaigns, the levels of vaccinial immunity declined steadily in almost all countries, as was documented during surveys conducted for certification purposes. Although not the intention, this proved, paradoxically, to be helpful in the certification process; with large numbers of susceptible persons, smallpox, if present, was more likely to spread and to be detected than it would in a well-vaccinated population.

Assessment

The WHO Handbook called for "a programme of continuing evaluation of coverage and vaccination take rates by an assessment agent (or team) who is administratively independent of the vaccination team". What was envisaged was a random sample survey of 10–25% of those vaccinated, to be conducted 1–4 weeks after mass vaccination had been completed in an area. The use of an assessor who reported to someone other than the vaccination team leader increased confidence in the reliability of the findings. Although other useful types of evaluation were proposed in the WHO Handbook and were used subsequently in the programme, an ongoing appraisal of this type provided the most important information for use in the quality control of the campaigns. Like surveillance, however, sample assessment was unknown to most health officials and was adopted only with reluctance. Most considered it wasteful of manpower and vehicles to create a team whose sole responsibility was to check the work of others. Many were more willing to provide sufficient personnel to re-examine the entire population and vaccinate those without vaccination scars, but this was rarely feasible or cost-effective.

Independent assessment, although not universally practised, was used to good effect in assembly-point programmes in Brazil and in a number of African countries, as well as in the house-to-house vaccination campaign in Afghanistan. The rationale of the methods and standards deserves comment. For a reasonably accurate appraisal of the quality of work in an area to be made, a random selection of villages was important, however crudely done, otherwise the assessment teams would visit the villages that were most easily accessible by vehicle and therefore the most likely to have the best vaccination coverage. The methods used for random selection varied widely, from a sophisticated approach in Guinea, in which villages were selected within a defined sampling frame and in proportion to population, to a much simpler one in Afghanistan, in which pieces of paper bearing the names of villages in which vaccination had been performed were placed in a box and the specified number drawn at random. The method of sampling was less important, however, than the fact that sampling was done and that teams were aware that their work was regularly checked and that, if the results were unsatisfactory, more work would be required. Most took pride in being able to meet or surpass the established goals.

The assessment teams also evaluated the efficacy of the vaccine that had been used, but only in the case of primary vaccination. The primary vaccination lesion was so distinctive that there was never any question whether vaccination had or had not been successful. With revaccination, on the other hand, there were many equivocal responses among persons with partial immunity, and their interpretation differed from observer to observer. Moreover, a standard for successful revaccination was impossible to establish because of the varying levels of immunity in different areas. For primary vaccination, a successful take rate of at least 95% was established as a minimum standard, a figure which permitted a margin of error in recording and observation because take rates normally approached 100% when a satisfactory vaccine was properly applied. The assessment of results of primary vaccination only had the further advantage that the response could be evaluated 1–4 weeks after administration, rather than in the 6–8 day period required to evaluate revaccination responses. More flexible schedules for the assessment teams were thus possible. In all but a few instances, primary vaccination take rates consistently exceeded 95%; where they were found to be

lower, problems of vaccine handling or vaccine quality were usually discovered which could then be rectified.

Coverage after a campaign was measured in terms of the proportion of the population with a vaccination scar or with evidence of recent primary vaccination rather than in terms of the proportion vaccinated during the campaign. It was simpler and more reliable to inspect a person, particularly a child, for the presence or absence of a vaccination scar or lesion than to ask whether the subject had been vaccinated during the team's visit. This simplified method was feasible because vaccinial immunity was so durable in endemic areas, even after a single primary vaccination. The standard of performance originally set by the WHO Handbook was that not less than 80% of the population should show evidence of immunity, as indicated by a vaccination scar. In most programmes, levels of 90% or more were common, the highest rates being among adults and older children. With time the methodology was changed so that in most countries only children under 15 years or even under 5 years were examined, but the criterion was retained that not less than 80%, and sometimes 90%, of that age group should have a vaccination scar or lesion. This approach was operationally advantageous because children were more likely than adults to be found in or near their homes when a visit was conducted. Given that older age groups consistently had even higher levels of coverage than the younger ones, a standard requiring evidence of immunity in 80% of children effectively ensured an overall population immunity of more than 90%.

The assessment data provided information on performance, but they were also used to guide operations, which was just as important. When it was found that vaccination coverage was below standard, teams were usually required to return to the area, sometimes without the payment of travel allowances, to revaccinate the entire population.

Other forms of assessment were also employed in the mass vaccination campaigns. One, used almost everywhere, was to compare the number of vaccinations performed in an area with the estimated resident population. This provided a rough indication of the success of the campaign but an unreliable one because the available population data for small localities were often highly erroneous and often many non-residents were also vaccinated. In some areas of western Nigeria, for example, where the number of vaccinations reported to have been performed corresponded to 80% of the population, sample surveys later showed that fewer than 40% had vaccination scars.

Another approach was to enter the names of all residents and their vaccination status in a register (as in India) or on cards (as in Zaire), in the expectation that, after the vaccination team had left, health staff could refer to the records and vaccinate those who had been missed. The preparation of such records, however, was exceedingly time-consuming; keeping them up to date proved all but impossible; and the effort required to find and to vaccinate every person who had been missed was prohibitive. All countries which endeavoured to register the names of vaccinated subjects soon abandoned the practice as being impracticable except the United Republic of Tanzania. There, what were called "ten-cell chairmen" prepared a list of all the inhabitants of their assigned area and, when vaccination teams arrived, called individuals forward one by one for vaccination. There were few countries, however, in which political or other organizations could assume such a burden of clerical work, and even in the United Republic of Tanzania the information was not retained as a permanent record.

Sample surveys to assess the status of immunity of selected population groups were undertaken periodically in a number of programmes. Such surveys proved useful for deciding on vaccination strategies for special groups and, on a larger scale, were important when it came to certifying the absence of smallpox. National and other large-scale surveys were performed in western Africa and in India but they proved of little value. National and, in Nigeria, regional surveys, conducted in western Africa in 1969–1970 to measure overall programme performance, revealed problems in some areas, but the information was obtained so long after the campaign had been conducted that the specific causes of the problems could not be identified nor corrective measures taken (see Chapter 17). In India, the forms and assessment methodology used in Afghanistan (see Chapter 14, Plate 14.3) were introduced in some states. It was hoped that health officers responsible for the house-to-house vaccination campaign would identify areas and

populations which had not been well vaccinated and would take corrective action. Although tens of millions of people were examined in the course of assessment exercises, most health officers saw the activity as an end in itself and took no action to correct problems. Large-scale surveys of this kind were gradually abandoned.

Progress in national programmes had traditionally been measured by the numbers of vaccinations reported each year. The data, compiled by administrative units, continued to be collected throughout the course of the programme but varied considerably in quality. In most areas, the vaccinations actually performed were counted, but in some, the numbers reported were equivalent to the assigned goals, while in others, they were estimated on the basis of the quantity of vaccine used. As the programme progressed, these data received less and less attention and greater emphasis was placed on trends in the numbers of reported cases of smallpox. By the early 1970s, data on the numbers of vaccinations reported each year and in each country ceased to be compiled in Geneva and, by the mid-1970s, interest in them was largely confined to the media, which regularly inquired about the numbers of vaccinations being performed. It proved preferable to give the reporters some estimate than to attempt to explain why such data were no longer available.

Legislation

Legislation on smallpox and vaccination existed or was adopted in most countries, but in most instances it proved to be of little benefit other than as an official statement of policy. In the majority of countries, legislation was enacted which called for compulsory vaccination at or shortly after birth, periodic revaccination, and the mandatory isolation of patients; some countries prohibited variolation and required citizens to report cases of smallpox. On the few occasions when action was taken to enforce such laws, the results were poor and often counterproductive. In India, for example, attempts to levy fines on persons who refused to be vaccinated led to protracted proceedings in the courts without any apparent increase in compliance by the general public. The forcible isolation of patients in hospital often caused many families to hide infected household members and impeded effective containment measures. The prohibition of variolation may have caused some variolators to abandon the practice but in Afghanistan, for example, it resulted in the general public refusing to supply information about them, making it more difficult to identify them and to persuade them to cease their activities.

Other forms of coercion, however, were occasionally needed and effective in special circumstances. For example, in crowded refugee camps, the rule that all persons should be vaccinated before being given food ensured rapid and complete coverage; during containment vaccination, a police presence often discouraged resistance to vaccination; and in Botswana the government's threat to expel a religious group from the country secured cooperation in accepting vaccination when other measures had failed.

The Surveillance–Containment Strategy

The history and rationale of the surveillance–containment strategy have been described earlier, as has its implementation at the global level. At the national level, the foundation for implementing the strategy was the network of reporting posts making up the national reporting system, complemented by mechanisms for the prompt investigation of cases and the containment of outbreaks. The WHO Handbook stressed the importance of establishing or strengthening a reporting network from the inception of each national programme but postulated that, in countries with a high incidence of smallpox, the available resources would not immediately permit the investigation and containment of all outbreaks. Although the Handbook recommended that a reporting system should be established in all countries as soon as possible, it proposed that, in countries reporting more than 5 cases per 100 000 population, case investigation should be limited to major outbreaks and to those in areas in which mass vaccination had been completed. In other countries, all cases were expected to be investigated and containment measures taken. In mid-1967, the data available showed that only 13 of the 31 countries in which smallpox was then endemic had rates of 5 per 100 000 or more, of which 6 were in western Africa (Dahomey (Benin), Mali, Niger, Nigeria, Sierra Leone and Togo), 4 in eastern and southern Africa (Burundi, Uganda, United

Republic of Tanzania, and Zaire) and 3 in Asia (India, Indonesia and Pakistan).

The belief that it would be some time before all reported cases could be investigated and contained rested essentially on 3 premises which, in most of the endemic countries, proved to be incorrect. The first was the notion that the level of vaccinial immunity in the population was universally low, especially in countries with a high smallpox incidence, and that mass vaccination would be necessary before the numbers of cases decreased sufficiently to permit each to be investigated. Overall vaccinial immunity in some countries was indeed low and mass vaccination campaigns did serve to reduce incidence, notably in Afghanistan, Brazil, Ethiopia, Nepal, northern Nigeria and Sierra Leone. In 1967, however, half or more of the population of most countries were found to have vaccination scars, and among these countries were some which reported a substantial proportion of all cases. In India, Indonesia and Pakistan, more than three-quarters were already fully or partially immune because of past disease or prior vaccination. It was found there that the interruption of smallpox transmission was less closely related to an increase in the proportion of the total population with vaccinial immunity than to better reporting and containment measures. The second misconception was that, where smallpox incidence was high, cases would be so numerous and widely scattered that a great many teams would be required to investigate and contain the outbreaks. With few exceptions, it was discovered that smallpox cases, although far more numerous than reported, were clustered in comparatively small areas, so that relatively few surveillance teams were needed to investigate and contain them. Finally, it was believed that, in most countries, health units were so few and so scattered that reporting systems would have to be based primarily on reports from village leaders, teachers and the like, and that these systems would require considerable time and substantial manpower to establish. In fact, most countries, even many of the least developed in Africa, had a remarkably extensive network of health posts and far larger numbers of health personnel than the WHO Smallpox Eradication unit had expected.

Soon after the Intensified Programme began, it became apparent that surveillance–containment programmes could be developed reasonably quickly and that such systems could rapidly interrupt transmission. The findings in East and West Pakistan in the years 1965–1968, in eastern Nigeria in 1967 and in Tamil Nadu State (India) in 1968 showed that:

(1) The reporting of cases, although incomplete, was usually adequate to identify most large outbreaks; many other cases could be readily discovered by a few field teams through the investigation of reported cases and by questioning health staff and villagers.

(2) Patients with smallpox usually transmitted the disease to very few people and only to those in close face-to-face contact. Transmission in markets or schools, for example, was uncommon. Outbreaks therefore tended to be clustered among acquaintances in certain parts of a city or areas of the country rather than being widely and randomly dispersed.

(3) Only persons with a rash were able to transmit infection to others; this made it comparatively simple to trace the chain of transmission from person to person.

(4) Where, as was the case in most countries, there was significant seasonal fluctuation in smallpox incidence, few persons or villages were infected during the season when transmission was at a low level; the discovery and containment of outbreaks during this season substantially reduced the number of cases in the subsequent smallpox season.

(5) Outbreaks could be easily and rapidly contained in most areas with a high degree of success by isolating the patient and vaccinating contacts and most persons in the immediate vicinity.

Given also that smallpox was so distinctive that it could be diagnosed reasonably accurately by villagers themselves, that there was an incubation period of fully 10–12 days between cases, and that the vaccine provided more durable protection than had been believed, the conditions for an effective surveillance–containment programme were unusually favourable.

Nevertheless, however logical and attractive the surveillance–containment strategy appeared to be, it was not readily accepted by programme directors. In part, the difficulty lay in understanding and accepting what seemed to be a simple concept—that all cases of smallpox were links in an identifiable continuing chain of infection and that, in every area, there was a finite, usually small

Plate 10.28. Careful questioning of villagers could usually reveal the source of infection of the first case in an outbreak of smallpox, but it was not always easy to tell from their directions where and how far away the person concerned might be.

number of chains. If a 2-week interval between cases is assumed, a single chain of transmission in a country would result in not less than 25–50 related cases in the course of a year. Even in countries with many cases, the number of chains of infection would not be large; a country with 500 cases a year would have no more than 10–20 such chains. Because the cases were so closely related to one another, the strategy required not only the containment of each outbreak but also the discovery of the antecedent cases and outbreaks in the chain and their containment. The lack of comprehension of this principle during the early years of the programme was indicated by the frequent reference by many programme directors to the occurrence of "sporadic" cases rather than to cases whose source of infection could not be found.

At the outset it was difficult to convince the authorities of the usefulness of setting up surveillance teams staffed by competent senior health personnel, although many created "fire-fighting teams" of poorly supervised vaccinators whose task was to administer vaccine when epidemics were discovered. Even when demonstration programmes were conducted by its most enthusiastic proponents, the surveillance–containment strategy was slow to gain acceptance. In western and central Africa, Dr William Foege and his colleagues tried to introduce it from the summer of 1968 but, as is recounted in Chapter 17, northern Nigeria, the most heavily infected area, did not participate. In 1968 and 1969, Dr A. R. Rao enthusiastically described his successful experience in interrupting transmission in Tamil Nadu State (see Chapter 15), but he did not succeed in persuading other state programme directors in India to follow his example; in Brazil, the achievements in 1969 of Dr Ciro de Quadros and his colleagues were likewise disregarded (see Chapter 12). Precisely when country-wide surveillance–containment programmes were fully implemented is difficult to say, but approximations are possible for the most populous countries. In the endemic countries, the first were those in western and central Africa, which began late in 1968. These were followed by Afghanistan and Indonesia in 1969, East Pakistan in 1970, Brazil, Ethiopia and Zaire in 1971, Botswana and the Sudan in 1972, India, Nepal and Pakistan in 1973, and Somalia in 1977.

Before 1973, simple surveillance–containment measures were employed, and these are described first in the following sections. From 1973 onwards, with global eradication closer and more resources available, the techniques became increasingly sophisticated; that period is discussed later in this chapter.

Routine notification of cases

The foundation of the surveillance system was a weekly report from each health unit which documented the number of smallpox cases seen that week; if none was found, a report showing "nil" had to be sent. To simplify and encourage reporting, only the most basic facts about the patients were requested: name, age, sex, village (or urban district), date of onset of rash, and whether the patient had previously been successfully vaccinated (as shown by the presence of a scar). The information could be contained in one line on a form and the report was therefore termed a "line listing of cases". These reports were to be dispatched at the end of the week to an intermediate administrative

unit (a state or province in smaller countries, a district in larger ones) and so on up the echelons, eventually reaching the national programme office. Each week, the national office reported to WHO Headquarters by telex or by mail the number of cases of smallpox by week of report and by district and state or province.

The system was designed to provide only the information that was relevant to programme operation at each administrative level. To check that the system was operating correctly, all units at each administrative level were expected to submit a report whether or not cases of smallpox had been detected. Numbers of deaths were not requested because progress in the programme was monitored in terms of smallpox incidence; the action to be taken, such as investigation and containment, was related to the occurrence of cases rather than of deaths. The information provided by the line listing, which was necessary for the investigation of cases by the surveillance teams, was of the greatest value at state or provincial offices in smaller countries or district offices in the larger ones. To facilitate the transmission of data by telegram or telex, higher-level administrative authorities received current data only on the numbers of cases by administrative unit. More detailed epidemiological information was usually collected and analysed nationally, but at a later stage.

In the notification system, all cases, irrespective of date of onset, were supposed to be recorded according to the week in which they were detected. In most countries, this meant the week in which they were seen by the health unit. A record system of this type was simple to operate and worked far better than one in which an attempt was made to record and tabulate all cases according to week of onset of illness.

In 1967, reporting practices varied widely from country to country; none followed precisely the pattern described above, but many had a reporting structure by which each health unit provided some sort of report weekly or monthly. This often entailed notifying cases of 25–50 diseases together with a variety of data on the operations of the health units. The reports were seldom used for operational or supervisory purposes and efforts were rarely made to ensure that they were submitted promptly or even that all units reported. At intermediate administrative levels, the situation was little different. Special notification systems were sometimes prescribed for the diseases subject to international quarantine regulations, such as smallpox. Some required village leaders and others who became aware of a case of the disease to report it to the responsible administrative authorities, but this was seldom done. Telex or telephone notification of the quarantinable diseases to national or provincial authorities was also requested in some countries but, again, not consistently carried out. With smallpox, there were other problems. Some health units diagnosed mild cases as "variola minor", considering them not to be "true smallpox", and did not report them. Where, as in India, the occurrence of cases was taken as evidence by supervisors that the vaccination campaign had been inadequate, health units suppressed reports of cases. In all countries, there was such substantial underreporting that it is not surprising that many countries believed smallpox to be a much less serious problem than it was.

The development of fully satisfactory notification networks took not less than 1–2 years. In many countries, this was facilitated by epidemiologists or mobile surveillance teams, each of which could usually cover an administrative area with a population of 5–10 million. The teams regularly visited each health unit to explain the programme, emphasize the need to report cases, encourage vaccination, distribute forms and vaccine, and check on late reporting. When cases were reported, the team investigated and contained the outbreaks, sometimes with the help of those at the health unit, and usually discovered many additional cases in the process. The frequent visits to the health units by the mobile teams and their prompt response when cases were reported proved to be a great stimulus to reporting, especially because other supervisory health staff rarely visited health units. Interest was also stimulated by national surveillance reports, published weekly or monthly in many countries and distributed to health staff at all levels.

Of the many problems encountered in developing the notification network, two deserve mention because of their relevance to the development of systems for other diseases. The first was the difficulty of persuading health authorities of the need to receive regular weekly reports, even when no cases were found. Most assumed that if no report was received, no cases had been detected. Experience showed, however, that the units

that failed to submit reports were usually the least effective in performing functions of all types, including vaccination. It was in such areas that large, hitherto unknown epidemics were the most frequently discovered. The second problem, encountered only in India, related to the decision by government authorities to record all cases according to week of onset rather than week of report. This resulted in chaotic record-keeping at all levels of the health system and contributed to a significant underreporting of cases (see Chapter 15).

Reporting units, even in the smallest countries, numbered 100 or more, and in countries with large populations, more than 1000. In India, the largest of the endemic countries, there were no fewer than 8167 units reporting weekly to 397 district offices, which, in turn, reported to 31 state programme offices, and these to the national programme office in New Delhi.

Other mechanisms for case detection

Routine case notification by health units, however assiduous, provided only incomplete data on numbers of cases. While such data were useful when deciding on the allocation of resources and as a point of departure for field investigations, additional measures were required to detect most and eventually all existing cases. For various reasons, patients did not always go to health units: some lived too far away; many, especially with variola minor, were not sufficiently ill to seek medical attention; some believed, rightly, that therapy would be of little value; and some wished to avoid detection so as to escape, for religious or cultural reasons, compulsory hospitalization or vaccination of household contacts. Not surprisingly, few patients came to health units in areas in which their dwellings were burnt as a prophylactic measure.

Help in detecting cases was sought from other health staff as well as from the government and private individuals. Health workers who moved from village to village in the course of family planning, malaria, leprosy or yaws control programmes should have been a useful source of information, but few contributed significantly until a reward was offered for detecting cases of smallpox. At different times and in different countries, appeals to report suspected smallpox cases were also made to administrative officials, religious leaders, development officers, agricultural extension workers and police and security forces; although many were helpful in other ways, their assistance in reporting on smallpox was minimal.

The most effective mechanism for detecting cases not seen at health units was the field investigation of the cases which had been reported. This was usually one of the first measures to be undertaken as surveillance programmes developed. Because the spread of smallpox tended to be limited to close personal contacts, many additional cases could usually be quickly discovered among the family and village or neighbourhood contacts of a case. By careful questioning of the patients, sources of infection in other villages could be identified and investigated. In Brazil, for example, the investigation of each reported case brought to light an average of 50 other cases.

As the Intensified Smallpox Eradication Programme progressed, it became apparent that the discovery of cases through routine reporting and the investigation of outbreaks were still inadequate. Many outbreaks were large by the time they were found and had already spread to other areas. Monthly or semi-monthly visits to all villages would have served to detect cases earlier, but in most countries it would have taken a year or more to visit every village, even briefly, given the number of the smallpox eradication staff.

Methods were therefore required to permit the staff to search rapidly for cases over wide areas. Among the first of the methods developed were inquiries by workers in schools and markets. Schoolchildren proved to be an exceptionally good source of information, being well informed as to who in their villages was ill and with what diseases and tending to be more forthcoming with information than adults. Surveillance teams were able, in a brief visit to a school, to question children from villages as distant as 5–10 kilometres. This approach, developed in Indonesia in 1969 (see Chapter 13), eventually became standard practice in all surveillance programmes. Akin to this approach was the questioning of those attending weekly markets.

When the numbers of outbreaks in a country or area decreased to very low levels, it became possible to search for cases among those who had been exposed to patients but had left the area. Tracing such contacts was difficult and not especially productive: com-

paratively few contacts became ill, since many were already immune or had not been sufficiently exposed to become infected. This technique was seldom used, therefore, even when there were few outbreaks.

The techniques for case detection described above were adequate for programmes in most countries of Africa and South America as well as some in Asia, but in the densely populated areas of Asia additional measures were adopted. Village-by-village and even house-to-house search became possible when additional staff could be recruited. The first village-by-village search was conducted in Indonesia in 1969 and the technique was employed thereafter in high-risk areas (see Chapter 13). It began to be used in India in 1972 and was extended nationally in 1973 (see Chapter 15). It then became the standard practice in the remaining endemic countries.

Data analysis and surveillance reports

Important elements of the surveillance process, as described in the WHO Handbook, were "the concurrent analysis and interpretation of reported data and studies" and the "widespread dissemination of the compiled and interpreted data to principal reporting sources and to others concerned with disease control activities". Although such activities might appear to be logical and routine in any systematic data collection process, they were uncommon at first in the endemic countries. This reflected, in part, the fact that progress in smallpox programmes had been measured by numbers of reported vaccinations rather than by numbers of cases of smallpox, and, in part, the disdain commonly felt by health officials for routinely collected morbidity data, which are everywhere recognized to be incomplete. Rather than using the information that was available, while at the same time trying to improve the system, such officials took little notice of the data.

Routinely collected morbidity data, incomplete and biased though they may have been, proved of value from the beginning of the programme and, as they improved, became ever more useful. Vaccination campaigns in most countries began in the areas that reported the largest number of cases and, in some, smallpox was eliminated before the national campaign came to an end. When cases were found primarily among children less than 15 years of age, the campaign strategy was altered to focus particularly on the vaccination of children. The early observation that most cases of smallpox occurred among persons who had never been vaccinated led to the studies previously mentioned which showed that vaccinial immunity was far more long-lasting than had been appreciated and to a consequent emphasis on primary vaccination. Many other illustrations of the usefulness of morbidity data could be offered.

In addition to the international surveillance reports, already described, national surveillance reports were also prepared and had a major impact on the various programmes. The first of these was a weekly mimeographed report, which was started in Brazil in 1967 (see Chapter 12). When special surveillance teams began discovering large numbers of unreported cases, it described what appeared to be a developing epidemic and this in turn attracted the attention of the press together with renewed political commitment and increased resources.

Containment

The containment of an outbreak was, in principle, straightforward, calling for isolation of the patient, vaccination of the members of his household and other contacts, investigations to determine if there were other cases in the area and identification of the source of the outbreak so that it, too, could be investigated and contained.

Before 1967, the responsibility for, and the methods used in, investigating and containing outbreaks differed from country to country. In most, local health officers were expected to initiate the necessary control measures, although national vaccination teams were sometimes deployed. Where variola major was present, mass vaccination was widely used when large outbreaks occurred, but smaller outbreaks were usually ignored. Special measures were seldom taken against the mild variola minor form. Patients usually remained in their homes or, where hospitals existed, were confined to a smallpox ward or a general infectious diseases ward. Special investigations to identify all cases or to determine the source of infection were practically unknown. If the patient recovered, it was sometimes the practice to disinfect surfaces in the room by scrubbing them with a formalin solution or carbolic soap and to burn the patient's clothing and bedding. In some places the practice was to

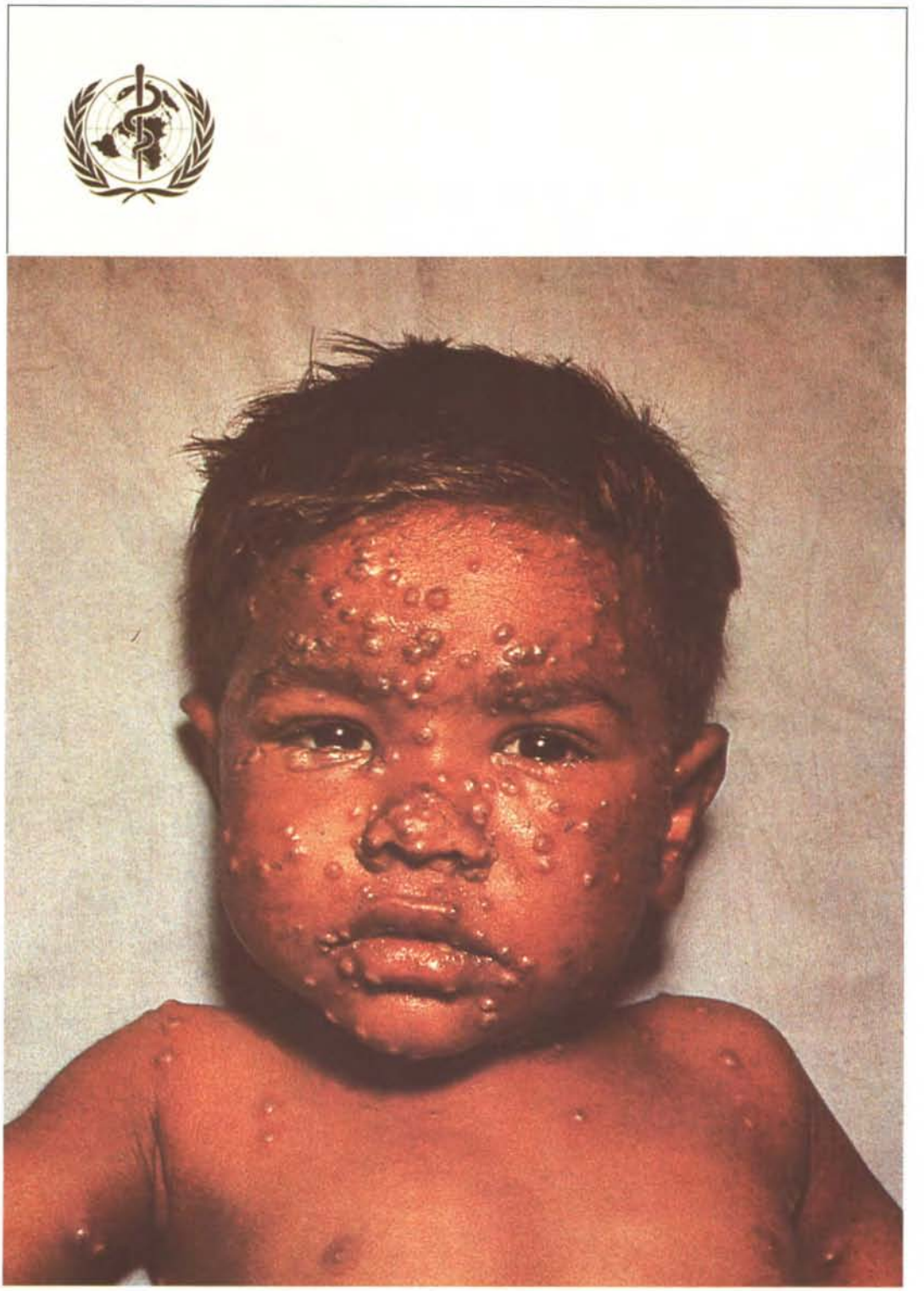

Plate 10.29. Front of the WHO smallpox recognition card that was widely used from 1971 in endemic countries. Smallpox eradication workers searching for cases would show the card and inquire whether anyone had seen a person with a similar rash.

Plate 10.30. Reverse of the WHO smallpox recognition card. It was on heavy-duty A4-size paper and cased in plastic for protection, unlike the pocket-sized version shown in Plate 10.11. In Ethiopia, a variant was used that showed an Ethiopian patient with variola minor.

Plate 10.31. Schoolchildren in Somalia (**A**) and in India (**B**) are shown the WHO smallpox recognition card and asked if they know of cases. Information about possible cases within a radius of 10 kilometres or more was frequently obtained in this way.

burn all dwellings in which cases had occurred.

The WHO Handbook devoted only 7 pages to a discussion of proposed containment and disinfection methods; the latter, quoted from Dixon (1962), were impracticable and, indeed, scientifically questionable. For example: "Letters: (*a*) Iron separate pages, both sides; (*b*) Expose loose pages and envelope to formalin vapour for three hours, then seal." The Handbook recommended that, in countries reporting fewer than 5 cases per 100 000 population, responsibility for containment should be given to a "knowledgeable person", defined as a trained epidemiologist. It recommended that the patient should be isolated, the source of infection identified, and household contacts vaccinated as well as "several hundred to several thousand persons ... in a brief intensive effort". It had little to say about the practical problems of containment, since there was little information in the published literature and those responsible for writing it had no practical experience of their own.

The diligence with which the containment of outbreaks was pursued after 1967 paralleled, in general, the development of reporting systems. Experience in executing containment measures gradually accrued as the programme progressed, but up to the end of 1973 the measures taken were comparatively simple ones, quite different from the disciplined methodology which began to be applied during the concluding stages of the programme in Asia and Africa in 1974.

Field experience showed that the isolation of patients in their own home or in a separate dwelling was usually the best practice. Because there was no effective therapy for smallpox, the hospitalization of patients was of little benefit. Moreover, hospitalized patients frequently spread infection to other patients, visitors and staff because hospital administrations regularly ignored isolation procedures. In fact, the authors are unaware of any institution in any endemic country, except one hospital in Madras (India), in which proper isolation practices were followed until they were introduced by smallpox eradication programme staff. So prevalent was the problem that programme staff often referred to hospitals as "smallpox transmission hospitals". Precautionary procedures were comparatively simple—the vaccination of staff and visitors, the isolation of all smallpox patients in a special ward and the vaccination of all such patients to protect any who might have been misdiagnosed. In most hospitals, however, smallpox patients were regularly accommodated in infectious disease wards with patients with other diseases or, at best, intermingled with chickenpox patients. Visitors usually came and went as they pleased and hospital staff themselves were frequently unvaccinated. Even late in the course of

Plate 10.32. Search workers used loud hailers at weekly markets, such as this one in Ethiopia, to seek information about possible cases of smallpox.

national programmes, infection in hospitals continued to occur, the last cases in Brazil and South Africa, for example, having been infected in this way. Indeed, the last case of endemic smallpox, in 1977, was in an unvaccinated hospital employee.

In most countries, the isolation of the patient in his home was both traditional and satisfactory but, in some, social customs led to the infection of many susceptible persons. Among some groups in the Indian subcontinent, for example, it was traditional for relatives and friends to visit those who were very sick, and in Indonesia young children with smallpox were often carried from house to house to be seen and comforted by relatives. Not surprisingly, simple containment measures were ineffective in these areas and smallpox spread rapidly. Interestingly, the most effective practices of patient isolation were found among scattered, illiterate African and Asian tribal peoples, who often arranged for the patient to be housed in a separate dwelling and to be cared for by someone who had previously had smallpox.

Special disinfection procedures after the patient had recovered were uncommon except for boiling or burning the patient's clothing and bedding; hospital rooms were cleaned in the ordinary way. Because few cases appeared to result from contact with fomites, no attempt was made during the programme to alter customary disinfection methods whatever they were.

The vaccination of contacts and the "several hundred to several thousand persons" in the area was fairly perfunctory until the programme was greatly intensified in 1974. Such vaccination was usually conducted during the main part of the day in the course of outbreak investigation. Inevitably, a number of residents, including household contacts, were away from home or their village at this time and so remained unvaccinated. Nevertheless, in Africa and South America, this brief but incomplete vaccination effort was usually sufficient to contain the outbreak eventually, even though one or several generations of cases might subsequently occur. In some countries, as cases became fewer, teams began to vaccinate early in the morning and in the evening to ensure more complete coverage, but seldom was a systematic effort made to enumerate and vaccinate all residents.

Attempts to trace the source of infection were sometimes made but were not always successful, special skills and diligence being required in questioning the patient, his family and friends. It was especially difficult to obtain such information, for example, from persons engaged in illicit activities such as smuggling or from people who had acquired the disease from prostitutes. A few programme staff, however, acquired an unusual mastery of the technique of tracing sources of infection and prided themselves on being able to identify the source of every

outbreak. Conversely, there were some otherwise competent epidemiologists who were consistently unsuccessful in this task; a few, especially early in the programme, simply characterized most cases as "sporadic".

Surveillance and Containment Measures after September 1973

From September 1973, the nature of surveillance and later of containment measures began to change significantly. By then, comparatively simple surveillance–containment operations and mass vaccination campaigns had been successful in stopping transmission in all but 5 countries—Bangladesh, Ethiopia, India, Nepal and Pakistan. Even in these countries, simple surveillance–containment measures had successfully eliminated smallpox from large areas, including much of southern India, Nepal and Bangladesh. Lack of progress in northern India and Pakistan, however, made it clear that neither country was likely to stop transmission without a more concerted effort. In the summer of 1973, therefore, a more elaborate system for case detection and subsequently for containment was devised by WHO and Indian staff which would involve large numbers of health service personnel, larger numbers of WHO and Indian epidemiologists, and greater financial support. Similar intensified efforts began late in 1973 in Pakistan, early in 1975 in Bangladesh, towards the end of 1975 in Ethiopia, and in May 1977 in Somalia when smallpox again became endemic there following importations.

Surveillance

In India, the persistence of smallpox despite high levels of vaccinial immunity was attributed partly to the high population density and partly to the frequent suppression of reports of cases by health staff. When, in 1974, the sources of all outbreaks began to be more carefully investigated, it became apparent that there was a third factor of significance—the frequent spread of smallpox over long distances. Of 6227 outbreaks for which the source was identified in 1974–1975, 1129 (18%) were found to have originated outside the state in which the outbreak had occurred and 25 outside the country itself (Basu et al., 1979). By comparison, data from Ethiopia, fairly typical of the experience in Africa, showed that the source of only 2% of outbreaks was outside the region (province) concerned (Tekeste et al., 1984).

It was believed that the key to eradication in the remaining affected areas was the more complete and the more prompt detection of outbreaks. Accordingly, it was decided to supplement the routine notification system by enlisting the participation of health staff from other programmes in national village-by-village, and eventually house-to-house, searches. Such searches had been shown to be effective in a district and in one state of India during 1972–1973 and, since large numbers of health staff were available in that country, it seemed reasonable to try to undertake them on a national scale. A detailed plan and guide were prepared which called for every inhabited locality in the search area to be visited in order to detect cases or to confirm their absence. In concept the plan was simple. The health staff in each administrative area would each be assigned 1–3 villages to visit each day. With the numbers available, an entire state could be covered within 7–10 days. After the search, the staff of the smallpox eradication programme, assisted by the local health workers, would contain the outbreaks which had been detected.

This proved to be feasible in Pakistan and Bangladesh as well as in India, but in Ethiopia and Somalia, with few health staff, temporary workers were required. Those from local ethnic groups, even the illiterate, who knew the topography and the people, proved to be the most effective—indeed, better than educated persons from urban areas. Considerable numbers were involved in each national search—more than 120 000 in India, 10 000–20 000 each in Bangladesh and Pakistan, and several thousands in Ethiopia and Somalia.

Training and motivating the large numbers of people involved were easier than had been expected. Training sessions of 1–2 days' duration were conducted before each search for personnel at the highest and intermediate administrative levels; subsequent sessions were conducted by intermediate-level supervisors for primary health centre supervisors, and, finally, by these supervisors for all health centre staff. Each intermediate and lower-level supervisor thus attended 2 training sessions, one as a participant and one as an instructor. At each meeting, the method of search was described

and, before the second and subsequent searches, the results and problems of the previous search were reviewed. The forms used were so designed that, when properly filled out, they guided each supervisor and search worker in carrying out his responsibilities.

The searches were conducted at different intervals in different areas—usually once every 4–8 weeks in endemic areas and once every 2–3 months in non-endemic areas. In the interval, additional search programmes were carried out in high-risk areas and in areas in which performance had been poor.

The development of a local search plan, in an area with perhaps 100 000–200 000 inhabitants, was the responsibility of the health officer in charge of that area. He selected the personnel to be employed and, using maps and demographic data, gave each worker 1–3 villages to visit each day on certain specified days. Those conducting the search travelled on foot or by bicycle. Some overlap in the sectors assigned helped to ensure that no areas were omitted. Usually, the workers travelled alone but in geographically difficult or dangerous areas a 2-man search team was used. A supervisor oversaw the work of 5–10 workers.

Through 1974, searches were conducted only in India and Pakistan and, until the autumn of that year, search workers were instructed to contact a number of different persons and groups in each village: the administrative head, postman, watchman and other local figures; people working in health units; children and teachers in schools; owners and customers of tea-shops; frequenters of markets; and persons at temples, mosques, churches, bus stops and similar places where people gathered in large numbers. The inhabitants of clusters of houses in each of 4 sectors of a village were to be visited, as were those in the poorest area. Although the more diligent workers were able to carry out all these activities, many did so perfunctorily, with the result that a number of cases failed to be detected. Overall assessment of the activities proved difficult, as did the identification of those performing inadequately. In the autumn of 1974, the numbers of cases and outbreaks had decreased sufficiently so that the method of search could be changed to one of house-to-house visits. A reward was offered and each search worker was required to place a poster or to paint a notice publicizing the reward on every tenth house, as well as on the schoolhouse. The quantity of forms, reports and posters required for each national search was considerable, one estimate in India indicating the need for a total of 8 tonnes of paper.

To ensure that the proper questions were asked, each search worker was trained to use a particular approach: he was to introduce himself as a health worker, explain the reason for his visit, show the WHO smallpox recognition card, inquire about suspected smallpox cases and tell the people about the reward and where to report suspected cases.

When a suspected case of smallpox was found, the search worker immediately notified his supervisor or the nearest health unit so that a containment team could begin work. In Ethiopia and Somalia, in which the population was widely scattered, search workers usually carried vaccine and were instructed to begin containment vaccination when a suspected case was found. The periodic discovery of suspected cases was important in sustaining the interest of the workers, but in areas which had become smallpox-free, interest was sustained and a mechanism of assessment provided by requiring them also to look for cases of chickenpox and measles and to detect and report all deaths accompanied by skin rash. This also provided added assurance that smallpox had not returned.

Special searches had to be devised for Somalia and other areas such as the Ogaden desert in which groups of nomads were

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Plate 10.33. Checking a bus station in Chotanagpur, India, for cases of smallpox. Regular checks of travellers by surveillance teams provided information about possible outbreaks over a wide area.

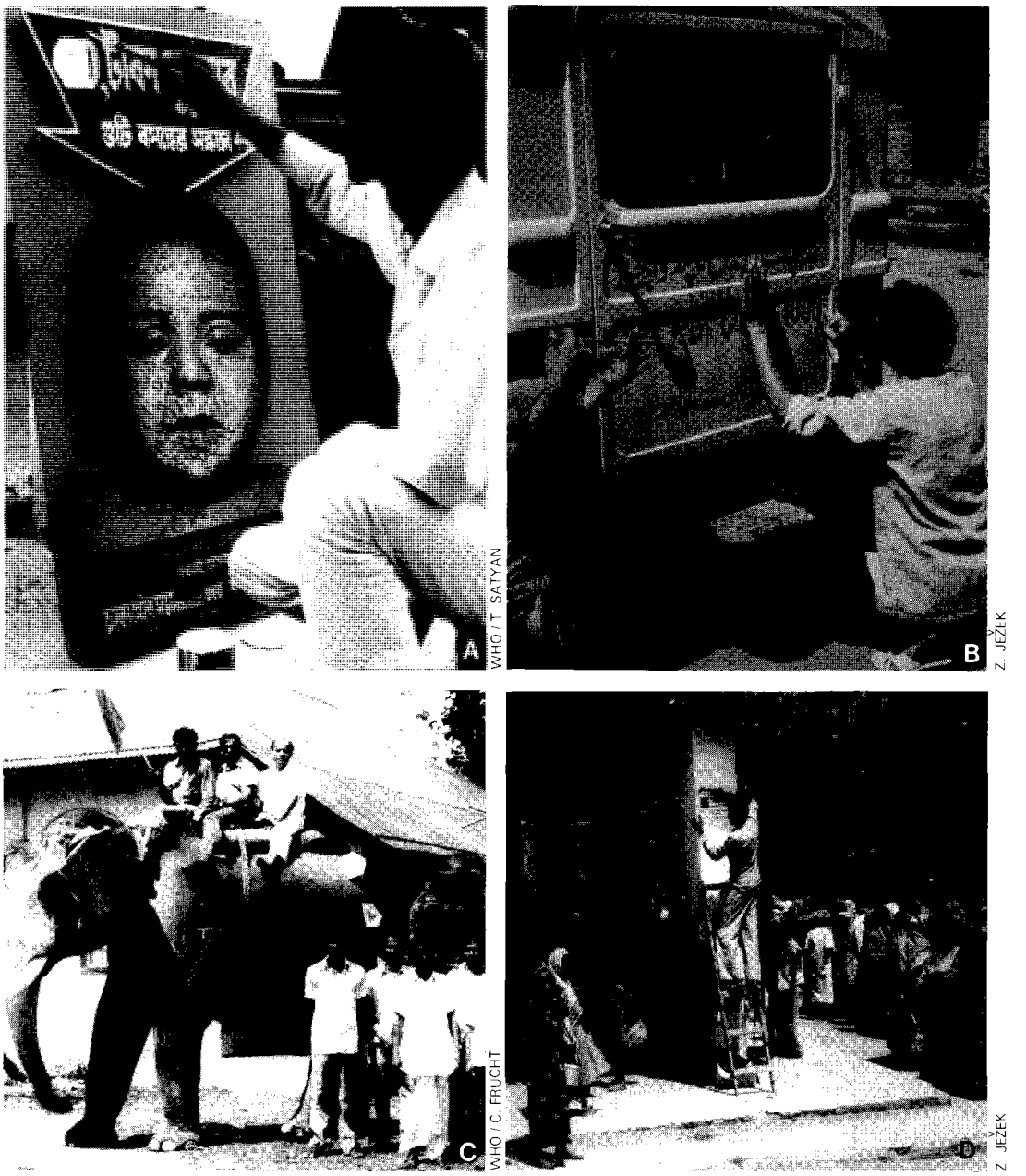

Plate 10.34. Publicizing the reward for reporting a case of smallpox. **A:** Repainting a poster in Bangladesh to show an increase in the amount of the reward. **B:** Painting a reward notice on a vehicle in Kashmir, India. **C:** Advertising the reward on an elephant in Assam, India. **D:** Hanging a reward poster in Somalia.

continually on the move. As is described in Chapter 22, different approaches were used to ensure the coverage of large areas while at the same time ensuring adequate supervision and assessment. In these areas, teams of 2 regularly walked long distances—50–150 kilometres—usually carrying vaccine so as to vaccinate any nomads encountered.

The organization of searches in urban areas was complex, and ingenuity was needed to coordinate the activities of the many and varied groups who usually participated, including numerous categories of municipal health staff and sometimes medical students, trainee nurses and volunteers from public services.

An intensive publicity campaign before and during the search, including the use of loudspeakers on cars and rickshaws, slides for projection, radio announcements, newspaper articles, handbills and posters, was found to be important in obtaining cooperation. As in rural areas, house-to-house searches were conducted, but schools, markets, factories and private medical practitioners were also visited. Special attention was given to areas in which migrants lived and to poor neighbourhoods. In urban areas, it was found that a search worker could visit 150 houses a day or about 1000 houses a week; 10 search workers with 2 supervisors were required to search an urban area with a population of 150 000.

Continuing assessment of search operations was as important as independent assessment of mass vaccination campaigns, as became apparent after the first search in India. Supervisors reported that 90% of villages had been searched and, indeed, thousands of previously unreported cases were detected, but a separate assessment by surveillance teams discovered that less than half the total had, in fact, been covered. An assessment programme was therefore developed which provided for independent appraisal of 5–20% of the localities by higher-level health officials and special teams. Where it was found that less than 85% of villages or urban sectors in an area had been searched, the entire search process was repeated in that area. As time passed, the minimum standard was raised to 90% and the areas chosen for assessment were deliberately selected to include those least likely to have been well covered, such as the villages furthest from health units and those with a high proportion of migrants or very poor populations. Similar approaches were adopted for assessment in the other countries.

The initial assessments were comparatively simple to make, being based on the statement of the village leader or the villagers themselves that a search worker had been in the area and the finding of a smallpox poster or marking on a wall (Plate 10.35). More sophisticated assessment became possible when house-to-house searches began and a reward was offered. Individual households were then asked whether they had been visited by a search worker, whether they knew the amount of the reward and whether they knew where to report cases of smallpox. Later, when workers endeavoured to detect cases of measles, chickenpox and other

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Plate 10.35. In some villages and towns, as here in Barisal, Bangladesh, search workers made a special mark on the wall of every fifth or tenth house. This was evidence for the assessment teams that the area had been visited.

illnesses with rash, the incidence of these diseases in different areas was compared and those in which few such cases were reported were searched again by special teams.

Assessment itself involved large numbers of people. In India, for example, 3 million households in 107 000 villages were routinely visited following each search. The numbers were smaller in Somalia, but finding the scattered villages and nomad camps made the task no less challenging.

The value of assessment in the search programme suggested its possible use for other purposes; this was demonstrated in Bangladesh (Joarder et al., 1980), in which teams also evaluated the availability and utilization of tube-wells in rural areas, contraceptive pills (and public awareness of family planning methods), and rural health centres. In other areas, data regarding the occurrence of measles, tetanus, poliomyelitis and blindness were obtained.

Surveillance teams were especially important in the planning and assessment of the search programmes and in other types of search procedure. Until 1973, there had been few of them in Asia, and they had been inadequately supervised and primarily responsible to state or district authorities; from 1973 to 1975, their numbers grew rapidly, proportionately more being assigned to areas in which smallpox was endemic. Those responsible for surveillance over the largest

areas were directed by a national or international epidemiologist, each with a vehicle, and accompanied by a health inspector, 1–2 vaccinators and a driver. At intermediate levels, the teams were headed by young physicians or health inspectors, also with a vehicle, and in some heavily infected local areas 3–4 vaccinators with bicycles or motor cycles constituted a team. The best of the supervisory staff and vaccinators were selected for the teams and trained over a period of 1–2 weeks, followed by supervised field experience under a programme epidemiologist. In Ethiopia, in which health personnel were few, the programme relied from its inception entirely on 2-man surveillance teams, each with a vehicle; most consisted of an Ethiopian health officer or sanitarian and a foreign volunteer. They enlisted the help of local health staff and others wherever they could be found, including young students who had been sent to work in the countryside. Somalia's surveillance programme, which started in 1977, relied primarily on teams headed by WHO epidemiologists and staffed by local health workers.

In each country, areas and groups were identified in which smallpox incidence had been or was then unusually high, together with groups which posed a threat of spread of the disease as a result of their migratory movements. Special searches by surveillance teams were scheduled, for instance, at construction sites, farms, refugee camps, nomad encampments and the poorer urban areas to which rural immigrants flowed. Border areas, whether between countries or provinces or states, were also found to be poorly served by their health administrations and were often areas of high incidence. Nomads could usually be intercepted at river crossings or mountain passes and sometimes also when they assembled to assist in the harvest. In Afghanistan and Somalia, special cards were issued to leaders of nomadic groups, certifying that the groups had been seen and vaccinated by a surveillance team, and indicating where and when they had been

SOO SHEEQ FURUQA

QAADO 200 SH

JAMHUURIYADDA DIMOQRAADIGA EE SOOMAALIYA
MASHRUUCA CIRIBMIRKA FURUQA
DIIWAANKA BAAFISKA FURUQA

MAGACA MADAXA
Name of Headman

TAARIIKH DATE	MEESHA LABAAREY WHERE SEARCHED		MAGACA BAAFIYAHA NAME OF SEARCHER
	MEESHA LOCALITY	DEGMO DISTRICT	

WAA IN LAGA HELAA AQALKA MADAXA

Plate 10.36. Leaders of nomadic groups in Somalia were issued with special cards on which search workers recorded when and where they had contacted the group.

Plate 10.37. The ceremonial presentation of a reward for discovering a case of smallpox in Kuralia, Bangladesh. The formality of a public occasion lent dignity to such events and attracted attention to the rewards.

contacted. The cards were subsequently useful in assessing the efficacy of search among nomads.

Special search programmes were required for areas especially difficult of access. Each country had a number of such areas, usually with a small, widely dispersed population and few health services, where teams often had to travel by boat, horse or camel or to walk for one or more weeks. Where variola major had been present, as in Asia, it was possible through facial pockmark surveys to determine the recent past history of smallpox. Such surveys in Bangladesh, India, Pakistan and Nepal during 1975–1976 revealed only a few small outbreaks which had occurred earlier but not been reported (Ježek & Kanth, 1978; Nair, 1978; Basu et al., 1979; Ježek et al., 1978b; Joarder et al., 1980). This was partly because of infrequent contact between the inhabitants of these isolated areas and those of the more populated endemic areas and partly because of the traditional practice of isolating patients that was followed by many tribal peoples.

The remote areas of Ethiopia and Somalia presented a different challenge. Variola minor had been present in these areas during recent decades, rarely leaving persistent facial pockmarks. Because the disease was mild, patients were usually not isolated and smallpox persisted for long periods. Repeated searches were required to confirm the absence of smallpox, and these were conducted in many areas of both Ethiopia and Somalia as well as in the southern Sudan (WHO/SE/74.67, Bassett et al.; Foster et al., 1978; Ježek et al., 1981; Tekeste et al., 1984).

Ultimately, the most effective method of ensuring prompt reporting proved to be to offer a reward. This had first been done in Indonesia in 1972, when a large outbreak was discovered in what was thought to be a smallpox-free area of Java (see Chapter 13). Numerous illnesses with rash were reported but none proved to be smallpox. Later that year the practice was adopted in Karnataka State in India, and soon thereafter in several southern states of that country, all of which were free or virtually free of smallpox. The rewards ranged from 10 to 25 rupees (US$1.30–3.25). The practice of offering a reward was slow to be adopted more widely, however, because many national and state

Table 10.11. India and Somalia: sources of reports of outbreaks

Source of report	India, 1974–1975		Somalia, 1977	
	Number of outbreaks	% of total	Number of outbreaks	% of total
House-to-house searches	1 946	62	52	37
Field investigations	928	29	9	6
Reports by members of the public	249	8	67	48
Other[a]	38	1	13	9
Total	3 161	100	141	100

[a] Includes market searches and other special searches by teams.

officials feared that it would establish a precedent whereby a reward would be expected for the report of any illness. This fear proved to be unfounded.

At the beginning of 1974, most Indian states sanctioned a reward of 50 rupees (US$6.25), rising to 100 rupees (US$12.50) at the end of 1974 and to 1000 rupees (US$125) in July 1975, shortly after the occurrence of the last case. The offer of even larger sums was considered but programme staff believed that too large a reward would cease to be credible. Even the amounts mentioned represented scarcely believable sums in a country in which workers were sometimes paid 10 rupees or less per day. Initially, the rewards were not well publicized by the health workers, who wished to keep them themselves; but the problem was resolved by offering 2 rewards, one for the person who reported the case and the other for the health worker who investigated it. Only 2 countries besides India offered a reward while cases were still known to be occurring: Bangladesh in mid-1974 and Somalia in April 1977. In Bangladesh, 220 000 takas (US$27 280) were paid in all, a modest sum for the improvement in reporting which occurred. The total expenditure in rewards is not known for India or Somalia, but it is believed to have been substantially less than in Bangladesh.

Rewards were also offered in other countries after they became free of smallpox but, although many suspected cases were reported, none was confirmed. Finally, in 1978, the World Health Organization offered a reward of US$1000 for the reporting of a case that could be confirmed; this, too, brought to light a great many suspected cases with rash due to many different causes. Although none proved to be smallpox, the offer of the reward was of value in confirming that eradication had been achieved.

Many approaches were used to publicize the reward but studies showed that the most effective was simply for search workers and surveillance teams to talk to the people. In surveys in both urban and rural areas of India, 70–85% reported that they had learned about the reward from a search worker; even higher figures were recorded in Somalia.

In 1975, when smallpox incidence had decreased to very low levels, other techniques were used in case detection. Health centres and hospitals were asked to enter the names and addresses of all suspected cases in a "rumour register" so as to obtain a record of such cases which could later be checked by surveillance teams; specimens were taken in increasing numbers from patients with chickenpox in order to ensure that errors in diagnosis were not being made; and surveys were conducted over wide areas to detect persons with facial pockmarks in order to determine whether any had had smallpox after transmission had apparently been interrupted. These activities continued throughout the certification period and were among the important steps taken to certify that transmission had been interrupted (see Chapter 24).

Of the many methods used to detect cases after 1973, in India house-to-house search was clearly of the greatest importance, followed by field investigations of the cases detected (Table 10.11). In Somalia, however, reports from the public in response to the offer of the reward previously mentioned were more important, that offer having begun to be publicized in April 1977 before house-to-house searches had been organized. Because of the reward, young nomads found it profitable to search widely for cases and many reports were received from them.

Containment measures after September 1973

In the change of strategy which began in the autumn of 1973, the initial concern was to ensure the prompter and more complete

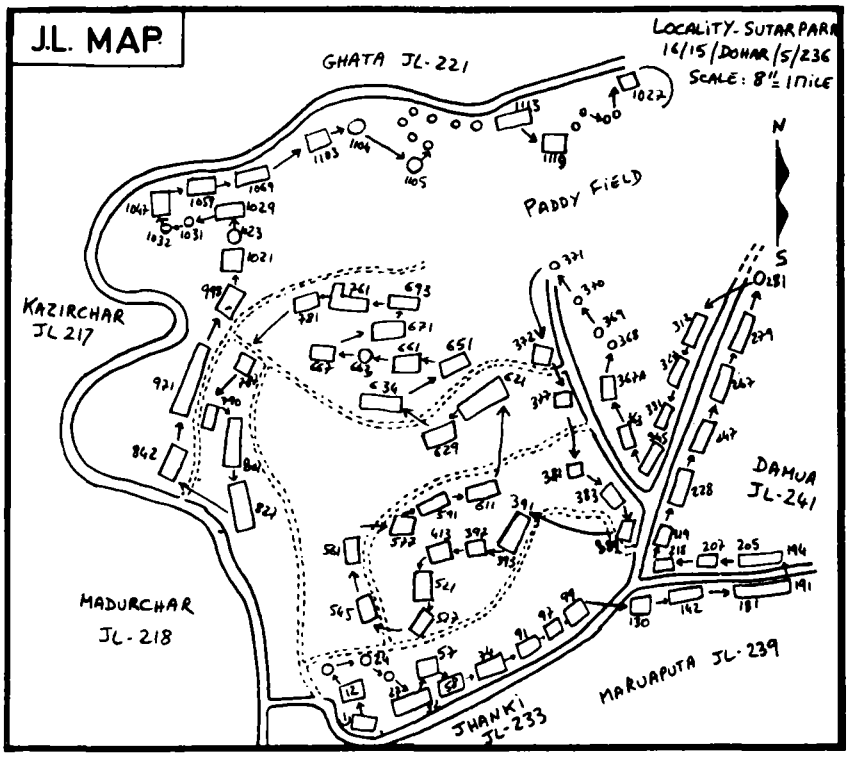


Plate 10.38. A sketch map of an infected village, prepared for containment activities in Bangladesh. All the houses were numbered; arrows indicated the order in which the houses were to be searched.

detection of cases. It was expected that the outbreaks could then be effectively contained by smallpox eradication staff in the conventional manner. The discovery of more than 10 000 cases in India during the first search in 1973 was unexpected and, in many areas, the numbers of outbreaks proved to be far beyond the capacity of existing staff to deal with. In heavily infected areas, help was at first sought from existing health staff but this often proved counterproductive, since those who discovered cases soon found themselves burdened with the additional task of containing the outbreaks. Accordingly, arrangements were made to ensure that those who searched were not also responsible for containment.

Because of the difficulties in developing search operations and the large numbers of cases, containment in all countries until the summer of 1974 continued to consist in little more than the isolation of the patient, a rapid survey to detect additional cases, and the vaccination of household contacts and those in some 30 surrounding households. It gradually became apparent that these measures were inadequate, since outbreaks which were thought to have been contained not only persisted but also spread to other areas. That summer, as numbers of smallpox cases decreased substantially, it became possible in India to assess carefully the failures in containment and to develop special measures to correct them. Over the succeeding months, containment measures became increasingly stringent, making it necessary to engage many additional workers, often locally recruited and trained. Other countries subsequently adopted similar measures.

Measures were taken to ensure more complete vaccination coverage in the outbreak area, the first step being to assign responsibility for each outbreak to a team leader who was a member of the smallpox eradication programme staff. He prepared a sketch map of the affected locality (Plate 10.38) and employed a team of local health workers to paint numbers on the doors of the houses or, in the case of tents, on WHO smallpox recognition cards, which were then attached to the entry flap of each tent. All residents of the village or district of a town were listed by name and by house before containment vaccination was begun, since it was found that fewer persons were then successfully hidden in an effort to avoid

vaccination. The vaccination programme, which followed the listing, required 1–3 days, the team leader and a number of vaccinators remaining in the village for 1 or more nights so as to vaccinate those who were absent during the day. Eventually, a vaccinator remained in an infected village for 28 and, later, for 42 days following the onset of the last case in order to vaccinate visitors, ensure that the patient remained isolated and detect promptly any additional patients who had been vaccinated too late in the incubation period to be protected. In Somalia, 1 or 2 vaccinators usually travelled with each affected group of nomads throughout this period.

For areas outside an infected village but within a radius of 8–10 kilometres, other teams moved from house to house to search for cases and to vaccinate. Because of the density of the population in many of the infected areas in Asia, this sometimes meant contacting 10 000 or more persons, a process that often took 1–2 weeks.

Wherever possible, patients were isolated in their houses, but even this required special measures. To ensure isolation, 4 guards were

Plate 10.39. **A:** Programme staff move from house to house to seek out cases and to register all persons resident in an Indian village. **B:** A WHO epidemiologist, L. B. Brilliant, shows the smallpox recognition card in Bihar State, India, and inquires about possible cases in the area. **C:** A surveillance worker records the discovery of an 8-year-old boy with smallpox in Sidamo, Ethiopia.

hired who were instructed that at least one of them must remain at the door of the house, day and night, entry being permitted through a single door, the other doors being nailed shut. They made certain that the patient remained in the house, vaccinated all visitors and brought the necessary food, water and firewood to the patient. Two at a time were expected to be on duty during each 12-hour period so that, if one had to leave, the other would remain. They stayed until the patient's last scabs had separated and were paid for their services at that time. Supervision was simplified by telling them that if, at any time, a supervisor found the house unguarded, all would be discharged without pay and new guards hired. Eventually a special book was provided in which the guards recorded the

Plate 10.40. **A:** A smallpox isolation hut in Baidoa, Somalia. **B:** An isolation camp for smallpox patients in English Bazar, West Bengal State, India.

name of each visitor, the date and the fact that he or she had been vaccinated.

In Ethiopia and Somalia, where many people lived in tents or small huts, and in congested areas of Bangladesh, it was difficult to isolate patients in this manner. In these countries, therefore, 2 other methods were sometimes used. The first was to construct for the patient a small separate hut with kitchen and latrine facilities and to surround it by a barrier of thornbush or bamboo. The second was to isolate the patient in a specially constructed camp occupied only by smallpox patients. Special guards were used in both cases. It was often difficult to gain the agreement of Ethiopian and Somali patients to be isolated, however, because, having the mild variola minor variety, they had few symptoms and could work and move about without difficulty. Compliance increased when all patients, on recovery, were given new clothes, their old clothes then being burnt.

From early 1974 onwards in India and later in Bangladesh and Somalia, larger numbers of national and international epidemiologists were recruited to head surveillance teams, with the aim of providing at least 1 such team for the supervision of surveillance and containment in an area with no more than 25 active outbreaks, an outbreak being defined as the occurrence of 1 or more cases of smallpox in a geographical location, such as a village, district of a town or nomad encampment. When a patient moved from one village to another—to be hospitalized, for example—this was counted as 2 outbreaks, since both areas had to be kept under surveillance. Once an outbreak was identified, it was considered "active" until 28 (later 42) days after the onset of the last case of smallpox. By this time, the patient's last scabs would have separated and any contacts who were incubating infection would have developed disease.

The surveillance teams were responsible for visiting each outbreak at least weekly to ensure that the prescribed measures were being taken; when the appropriate interval had elapsed after the onset of the last case, they were also responsible for organizing a search of the area lasting 1–2 days before certifying that the outbreak could be removed from the master list of active outbreaks.

Outbreak investigation required time and patience in order to identify with accuracy the dates of onset of all cases and the probable sources of infection of each so as to reconstruct its development. For this purpose, and to promote an understanding of the concept of the chain of transmission, a special form had been employed since 1970. As the number of epidemiologists increased and the number of outbreaks decreased, more elaborate forms began to be used.

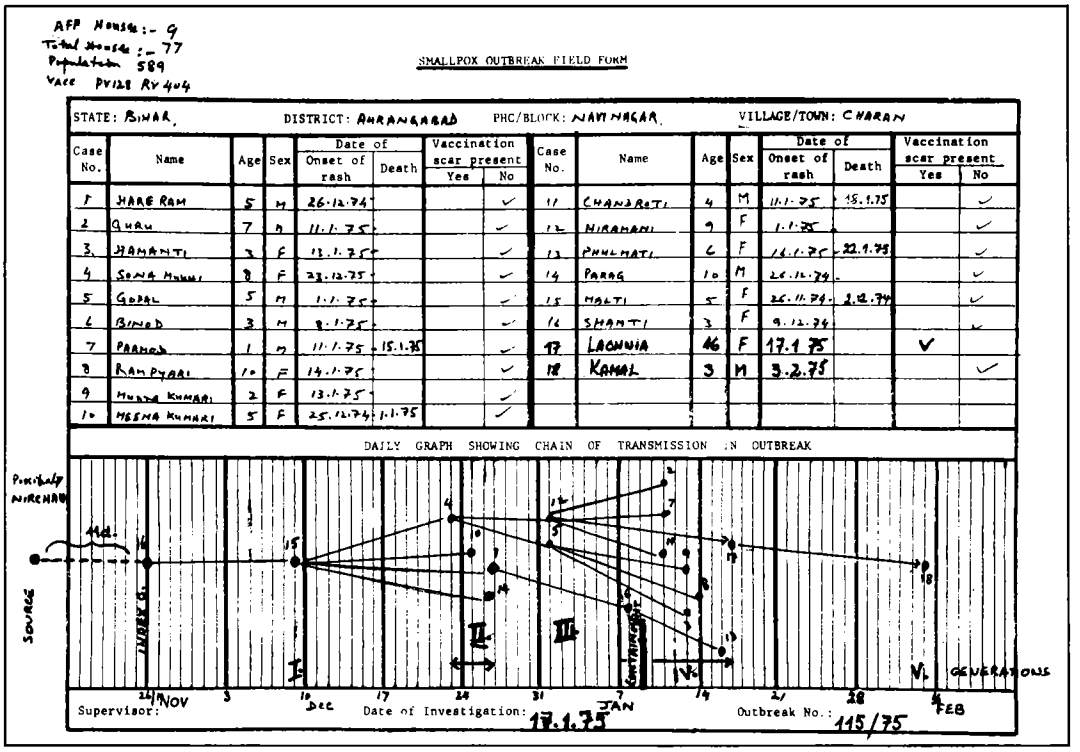
The surveillance team was responsible for investigating the source of infection or contacts of patients if they were in villages within its area of responsibility, but if the villages concerned were outside its area, the team notified its superiors so that other teams could investigate. However, the transmission of accurate information from one area to another regarding possible sources of infection and patient contacts proved unexpectedly difficult. The names of contacts as well as those of towns and villages often had to be spelled phonetically, since informants were usually illiterate. Whether this information was transmitted by telex, messenger or telephone, there were often difficulties in locating the persons or even the villages named.

The quality of supervision provided by the teams was proportional to the number of outbreaks and, as outbreaks became fewer, ever more intensive measures were applied, with the result that smallpox incidence showed an accelerating decline from June 1974 in India, and from the spring of 1975 in Bangladesh, when a similar approach was used there.

Measurement of progress

As has been noted above, it became the practice in 1973–1974 to record and monitor the number of active outbreaks rather than the numbers of reported cases. This focused the attention of programme staff specifically on surveillance–containment activities and, as a result, several standards for use in measurement were developed, designed to appraise the effectiveness of such activities.

The interval between the onset of an outbreak and its detection reflected the effectiveness of case detection. It was believed that it should be possible to detect at least 75% of all outbreaks within 14 days after the onset of the first case. This proved difficult. In India, a level of 57% was achieved during 1974–1975; in Bangladesh just over 70% in 1975; and in Somalia, 60% were discovered after intensive activi-



Case No.	Name	Age	Sex	Date of Onset of rash	Date of Death	Vaccination scar present Yes	Vaccination scar present No
1	HARE RAM	5	M	26.12.74			✓
2	GHAN	7	M	11.1.75			✓
3.	HAMANTI	3	F	13.1.75			✓
4	SONA MANJI	8	F	23.12.75			✓
5	GOPAL	5	M	1.1.75			✓
6	BINOD	3	M	8.1.75			✓
7	PRAMOD	1	M	11.1.75	15.1.75		✓
8	RAM PYARI	10	F	14.1.75			✓
9	MUNNA KUMARI	2	F	13.1.75			✓
10	MEENA KUMARI	5	F	25.12.74	1.1.75		✓

Case No.	Name	Age	Sex	Date of Onset of rash	Date of Death	Vaccination scar present Yes	Vaccination scar present No
11	CHANDRAVATI	4	M	11.1.75	15.1.75		✓
12	NIRAMANI	9	F	1.1.75			✓
13	PHULMATI	6	F	14.1.75	22.1.75		✓
14	PARAG	10	M	26.12.74			✓
15	MALTI	5	F	26.11.74	2.12.74		✓
16	SHANTI	3	F	9.12.74			✓
17	LACHHIA	46	F	17.1.75		✓	
18	KAMAL	3	M	3.2.75			✓

Plate 10.41. Form for outbreak investigation which provided in the upper part for basic data about cases and, in the lower, for plotting them by date of onset to show the spread from patient to patient. The roman numerals indicate the generations of cases. The outbreak plotted here occurred in Bihar State, India, in December 1974 and January 1975.

ties began in April 1977. However, by determining why in each instance the interval was longer than that prescribed, problems in detection were identified and the necessary changes in field operations could be made.

The response of containment teams was measured by the *interval between the discovery of the outbreak and the beginning of containment activities*. Ideally, containment should have begun on the day a case was reported, but this depended on the availability of manpower and transport. In most areas, there was a rapid response. In India, containment was started in 60% of newly discovered outbreaks on the day they were discovered; in less than 10% was it delayed for 3 days. In Somalia, containment was started on the day of discovery in only 40% of outbreaks when the programme began in April 1977 but in more than 90% by August.

The effectiveness of containment measures was assessed by the *interval, in days, between the beginning of containment and the occurrence of the last case*. This indicator was closely followed in all programmes from the autumn of 1974 onwards. The standard laid down was that no case of smallpox should occur in any outbreak more than 20 days after containment had started. This interval was long enough for containment vaccination to be completed and for smallpox to develop among those who had been vaccinated too late in the incubation period to be protected. From early in 1975, all outbreaks in which cases occurred more than 20 days after the start of containment activities were investigated by a senior epidemiologist to determine the reasons for failure and to advise on corrective measures.

The effectiveness of containment varied widely from area to area but improved with time. In India, additional cases occurred after 20 days in 25–30% of outbreaks in 1974, but in only 5% during 1975. In Bangladesh, a more rigorous interval of 15 days was prescribed as the standard. From November 1974, cases occurred in 25% of outbreaks after 15 days, a proportion which gradually decreased to less than 10% by June 1975. In Ethiopia, in 1973, smallpox persisted for more than 20 days in fewer than 25% of

outbreaks and the figure remained at or below this level until transmission ceased.

CONCLUSIONS

Smallpox had many attributes which greatly facilitated its elimination; the strategic plan for eradication was a comparatively simple and inexpensive one; and, in principle, all countries supported the concept of an eradication programme coordinated by WHO. As has been pointed out in this chapter, however, implementation of the smallpox eradication programme was neither simple nor straightforward, and its successful outcome, even as late as 1976–1977, was by no means assured. The execution of this global programme, like that of any other, was inevitably complicated by a host of natural and political problems ranging from floods, drought, famine and war to such human failings as incompetence, dishonesty and personal antagonisms. These alone gave rise to formidable difficulties. No less of a problem was that of obtaining and sustaining a commitment to the programme on the part of national governments and international agencies alike, however beneficial for all peoples the global eradication of smallpox was seen to be. In consequence, serious shortages of resources and lack of cooperation continually hampered progress. Although an understandable scepticism prevailed at first as to the feasibility of eradicating this or any disease, problems persisted even when it was clear that eradication was imminent and continued throughout the process of certification.

Nevertheless, the global eradication of smallpox was ultimately achieved, a success which can be attributed essentially to four factors. The first and most important of these was the existence of an international organization through which a collective international policy could be expressed and which could call on governments and individuals in fostering and coordinating activities directed towards a common purpose. Although the execution of the programme was sometimes less than optimum, no other agency could have obtained the requisite cooperation and international commitment and participation to achieve an objective of this magnitude.

The second important factor was the dedication and competence of a substantial cadre of both national and international staff, many in their 30s and 40s, who continually learned from experience—adapting, innovating and creating to enhance the programme's activities. They, in turn, served to stimulate and to inspire the large number of national health staff whose potential had never been fully realized.

The third factor was that the strategic plan was stated in terms of principles and illustrative methodologies rather than of directives. Moreover, the WHO Handbook explicitly encouraged programme staff to explore alternative approaches and anticipated that changes would be made as experience was acquired. As a consequence, each national programme was different and each evolved and changed over time. In addition, experiences and observations in one area were rapidly communicated to others and then appropriately adapted and applied.

Finally, the fourth factor was the recognition in 1967 that, however much was known about smallpox and however adequate the tools for eradication appeared to be, continuing research both in the field and in the laboratory would be essential. Thus, research was actively promoted throughout the course of the programme and scientists from all parts of the world responded to WHO's requests with extraordinary generosity and commitment, commonly making their observations available long before publication. Without the contributions provided by research, the achievement of smallpox eradication would have been doubtful at best.

The programme itself developed with surprising rapidity from 1967 to 1973, employing few international staff and comparatively straightforward methods of mass vaccination and surveillance–containment. In large measure, this success, where earlier efforts had failed, can be attributed to the use of quality control in the programme, something that had been uncommon in most of the endemic countries. Testing in international laboratories ensured that vaccine was potent and stable; assessment of vaccination campaigns determined whether the proportion of vaccination takes was satisfactory and the coverage adequate; and improved reporting systems provided evidence of progress towards the ultimate objective of the programme—the absence of smallpox cases.

In 1973, when endemic smallpox was confined to 5 countries in the Indian subcontinent and eastern Africa, increasing resources became available through voluntary

contributions, permitting an intensification of work in the problem areas. Surveillance–containment programmes in the 5 countries concerned became steadily more sophisticated and activities began to be documented in greater detail. Increasing numbers of international and national staff were recruited for full-time service and printed forms for recording data increased markedly both in number and in the amount of detail they contained. Without this effort, smallpox transmission would have persisted far longer than it did, if indeed eradication could have been achieved at all, given the population density and movements of peoples in the Indian subcontinent, war in Ethiopia, and the suppression of reports of smallpox in Somalia.

Until 1973, successful national programmes required only a few international advisers in addition to their own health personnel, and a handful of simple forms. Case detection and containment programmes were simple and relied heavily on existing health service units. This is not adquately reflected in the published literature, as most papers deal with programmes during the period 1973–1977 and suggest a pattern of activity which, although necessary then, was not characteristic of programmes in the more than 20 countries which succeeded in eradicating smallpox before 1973.

Chapters 12–22, which deal with national programmes, describe more fully the wide variety of activities carried out, the problems, the successes and the mistakes. What was apparent in all, however, was the potential for extraordinary achievement on the part of WHO and national health service staffs acting in concert, given proper guidance and appropriate support in coordination, management and the allocation of resources. The potential for success in eradicating smallpox was greater in 1967 than anyone initially believed; the potential for successfully applying measures for the control or elimination of other diseases is far greater 20 years later.

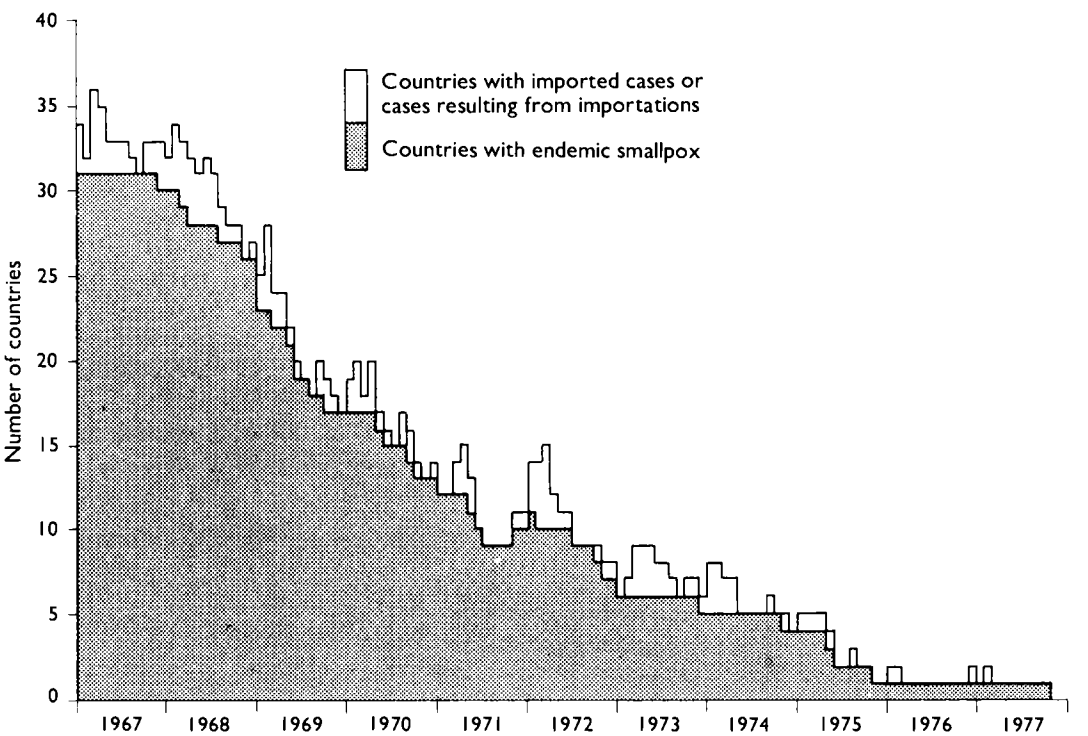


Fig. 10.4. Number of countries with endemic or imported smallpox, by month, 1967–1977.

A CHRONOLOGY OF PROGRESS, 1967–1980

Introduction

This section presents a year-by-year summary of progress in smallpox eradication (Fig. 10.4) to provide a frame of reference for the chapters describing the eradication programmes in individual countries or groups of countries (Chapters 12–23) and the certification of eradication (Chapters 24–27).

In compiling the data on the incidence of smallpox over the years, we have reviewed the available and sometimes conflicting reports and have made use of the figures that in our opinion most accurately reflect the situation at the relevant time. Some figures differ from those previously published and from those in the official national and international records. The differences are greatest for the early years of the programme, when notifications of reported cases were most delayed and incomplete. The reader who wishes to refer to the contemporaneous figures may consult the *Weekly epidemiological record*, which provided a compilation of the most recent information every 2–3 weeks and a summary of the status of the programme as a whole twice a year.

Throughout the course of the Intensified Smallpox Eradication Programme, particular importance was attached to defining which countries had endemic smallpox and which did not. Although this might seem a straightforward task, it was not so, especially during the first few years and for the smaller countries. The first summary of the situation in this period was provided in a report by the Director-General of WHO to the forty-first session of the Executive Board, which met in January 1968. In that report, 29 countries or territories were identified as being "endemic" (30 if East Pakistan, which later became Bangladesh, and West Pakistan are considered separately). Later information led to Cameroon, Southern Rhodesia and Yemen being added to the list; each had reported only a few cases in 1967 and these were at first assumed to represent importations, but they were not. However, 2 small countries—Lesotho and Swaziland—were mistakenly shown as having endemic smallpox in 1967 because of their proximity to infected areas in South Africa and their rudimentary reporting systems. Subsequent information suggests that both were smallpox-free. In later years, other countries were mistakenly identified as non-endemic because of government suppression of smallpox notifications. This occurred for Iran from 1970 to 1972, for Iraq from 1971 to 1972 and for Somalia in 1976. Later information received from government and other sources served to clarify the situation.

The Situation at the Start of the Intensified Programme, 1967

The first year of the Intensified Smallpox Eradication Programme saw a substantial acceleration of activities compared with previous years. This was primarily the consequence of greater financial resources and more staff becoming available from WHO and of the implementation of the regional programme in western and central Africa that received direct support from the USA. Certainly this enhanced effort started none too soon, for the number of reported cases of smallpox in the world rose in 1967 to 131 776, one of the highest totals for a decade. Little of this increase can be attributed to better reporting since few countries had yet improved their case-notification procedures. Indeed, it soon became evident that reporting was even less complete than had been feared; it had been thought that perhaps 1 case in 20 was being notified, but experience in the field began to indicate that a figure of 1 in 100 was probably nearer the mark.

The 31 countries or territories classified as having endemic smallpox (see box) were in 4 epidemiological zones sufficiently separate to make it unlikely that if one was freed from smallpox, it would become reinfected from another. These were: (1) Brazil, (2) Indonesia, (3) Africa south of the Sahara, and (4) a contiguous group of southern Asian countries extending from Afghanistan through West Pakistan, India and Nepal to East Pakistan. The eastern borders of East Pakistan and India were taken as the eastern limit of endemic smallpox on the Asian mainland, although Burma had imported cases from 1967 to 1969. The People's Republic of China was not in relations with WHO in 1967 and provided no official information, but reports by visitors suggested that smallpox was not present there; the government confirmed this in 1973.

Programme implementation

Basic strategies and principles were issued in July in a WHO *Handbook for Smallpox Eradication in Endemic Areas*, and these were endorsed in September by the WHO Scienti-

fic Group on Smallpox Eradication. Surveillance reports giving epidemiological information and documenting progress in the countries were widely distributed by WHO from September on.

WHO gave priority to the eradication programmes in the smaller of the major epidemiological zones—Brazil and Indonesia—in the expectation that success there would free resources that could be concentrated on the larger and probably more difficult zones. Brazil's programme had started in 1966, and Indonesia and WHO agreed in December 1967 on one to start in 1968. Eradication programmes began or were under way in 12 of the other 29 endemic countries at the end of 1967. Programmes in Cameroon, Dahomey, Ghana, Mali, Niger, Nigeria, Togo and Upper Volta were included in the regional western and central Africa programme supported by the USA; a programme in the Democratic Republic of the Congo started late in the year; and WHO-supported programmes were continuing in Afghanistan, Nepal and Zambia, although only the last of these represented a meaningful effort.

Many other countries decided to undertake programmes and developed plans of operations with advice from WHO; the procurement of supplies began as each plan was finalized. In India, however, a serious problem was posed by the government's decision in December 1966 to terminate its 5-year-old vaccination campaign. That country was then reporting more than one-third of the world's cases. Appealed to by WHO, it agreed that a joint India–WHO team should undertake a field assessment of the situation late in 1967 and develop an alternative plan.

Other developments

In May the first annual meeting of WHO regional and Headquarters officers responsible for smallpox eradication was held to discuss and agree upon plans, needs and priorities. In December there was held in Thailand the first of many intercountry meetings at which the staff of programmes in different countries and their WHO counterparts exchanged experiences and debated strategies.

The supply of potent, stable vaccine being crucial to success, arrangements were made for laboratories in Canada and the Netherlands to test vaccines and to help countries to develop their own production. At the same time, WHO initiated a survey of the vaccine quality and production capacity of laboratories throughout the world. More than 200 batches of vaccine were tested under WHO's auspices in 1967 (43 batches in 1966, 12 in 1965). All countries were asked to contribute vaccine and by the end of the year 15 million doses had been distributed by WHO, 4 times as many as in 1966. Over and above this, the USSR provided more than 75 million doses, mainly to Afghanistan, India and Burma, and the USA about 25 million doses for use in Africa.

After trying and rejecting several cheaper variants of the jet injector, which had come into operational use in 1967, WHO assessed the capability of the bifurcated needle—a new device by which a very small amount of vaccine could be introduced almost painlessly into the skin by multiple punctures. By the end of the year it had proved to be the instrument of choice.

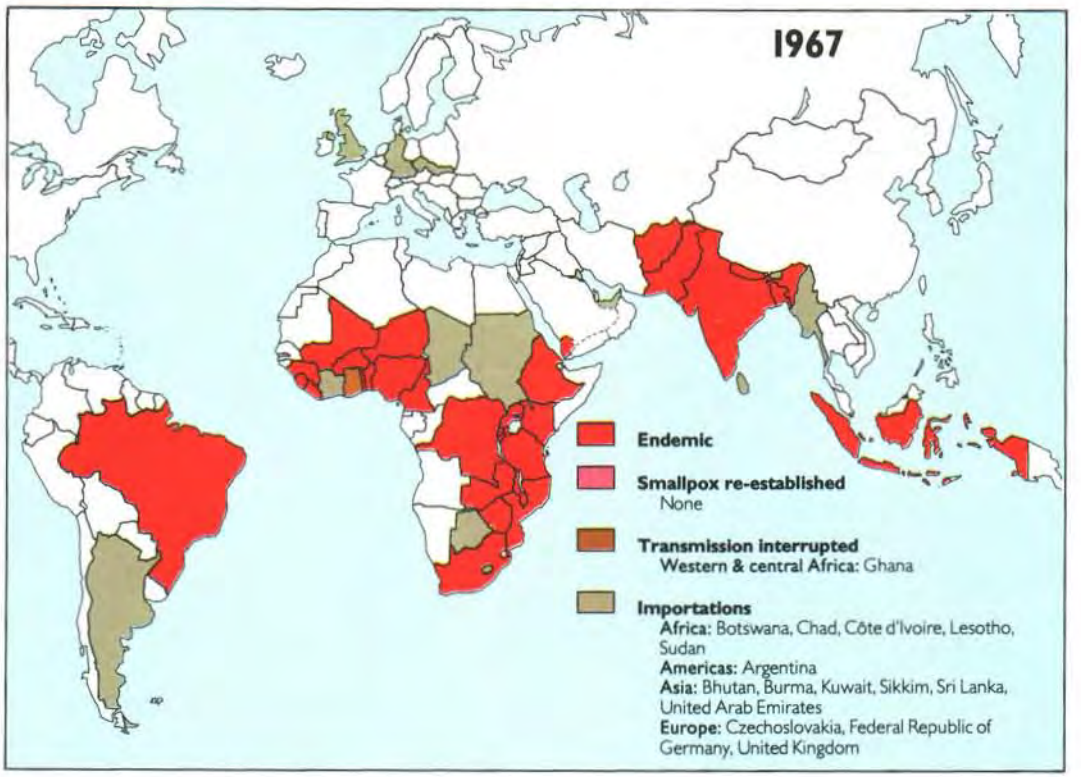
Countries or Territories with Endemic Smallpox in January 1967

Africa, eastern and southern: Burundi, Democratic Republic of the Congo (Zaire from 1971), Ethiopia, Kenya, Malawi, Mozambique, Rwanda, South Africa, Southern Rhodesia (Zimbabwe from 1980), Uganda, United Republic of Tanzania, Zambia.

Africa, western and central: Cameroon, Dahomey (Benin from 1975), Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Sierra Leone, Togo, Upper Volta (Burkina Faso from 1984).

Americas: Brazil.

Asia: Afghanistan, East Pakistan (Bangladesh from 1971) India, Indonesia, Nepal, Pakistan (West Pakistan until 1971), Yemen.



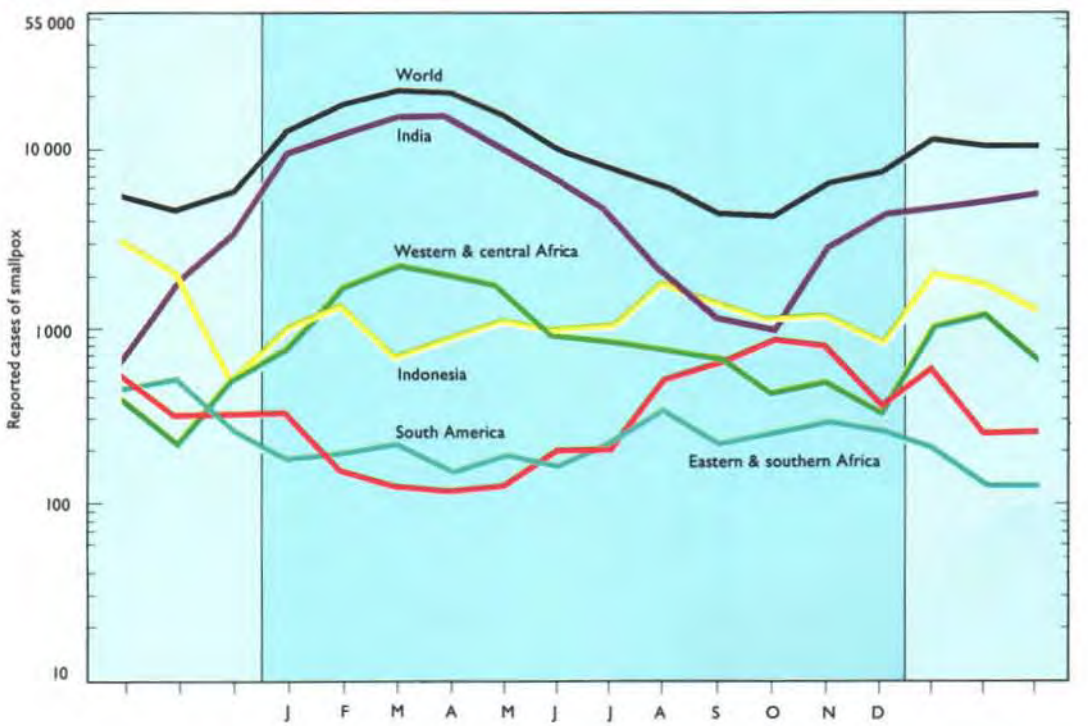


Plate 10.42. Smallpox in the world, 1967: endemicity in 31 countries or territories.

The Situation in 1968

During the second year of the Intensified Programme, the number of endemic countries with special eradication programmes increased from 12 to 19, and agreements were reached or appeared imminent for the commencement of programmes in 8 others. However, 4 remained as problems—Southern Rhodesia, South Africa, Mozambique and Ethiopia. The first two, with which WHO had no official contact, caused little immediate concern as they reported few cases and had a reasonably extensive health infrastructure. However, civil war in Mozambique precluded an extensive programme there, and Ethiopia declined to initiate a programme.

The number of countries with endemic smallpox in 1968 remained at 31, transmission having stopped in Ghana in 1967 but Sudan becoming infected following importations from Ethiopia. The number of reported cases diminished from 131 776 to 79 951 but this was almost entirely accounted for by a decrease in India (from 84 902 to 35 179 cases). Whether this represented better smallpox control in India or simply a longer-term cyclical trend in the incidence was unknown.

Africa

The most heartening progress was made in the regional programme in western and central Africa, which included some of the world's poorest and most heavily infected countries. By the end of 1968, 62 million persons had been vaccinated—almost 60% of the total population; in September special surveillance–containment programmes began in many of the countries. There was a sharp drop in the number of cases reported and 6 of the 10 remaining endemic countries interrupted transmission. However, civil war in Nigeria, the most populous country, threatened to extend throughout the country. In eastern and southern Africa, Uganda and Zambia also stopped transmission.

South America

Brazil, the only endemic country in the Americas, made notable progress in its vaccination campaign and, by the end of the year, was vaccinating 1.3 million persons each month. There was little improvement, however, in the notifications or the surveillance programme. Neighbouring countries in South America also conducted vaccination campaigns but cases—all due to importations from Brazil—were detected only in French Guiana and Uruguay.

Asia

The programme in Indonesia began in 1968 and within 6 months transmission was interrupted throughout East Java, a province with more than 25 million persons. Although special vaccination campaigns were begun or intensified throughout Indonesia and other endemic Asian countries, progress was generally poor and reporting was little improved.

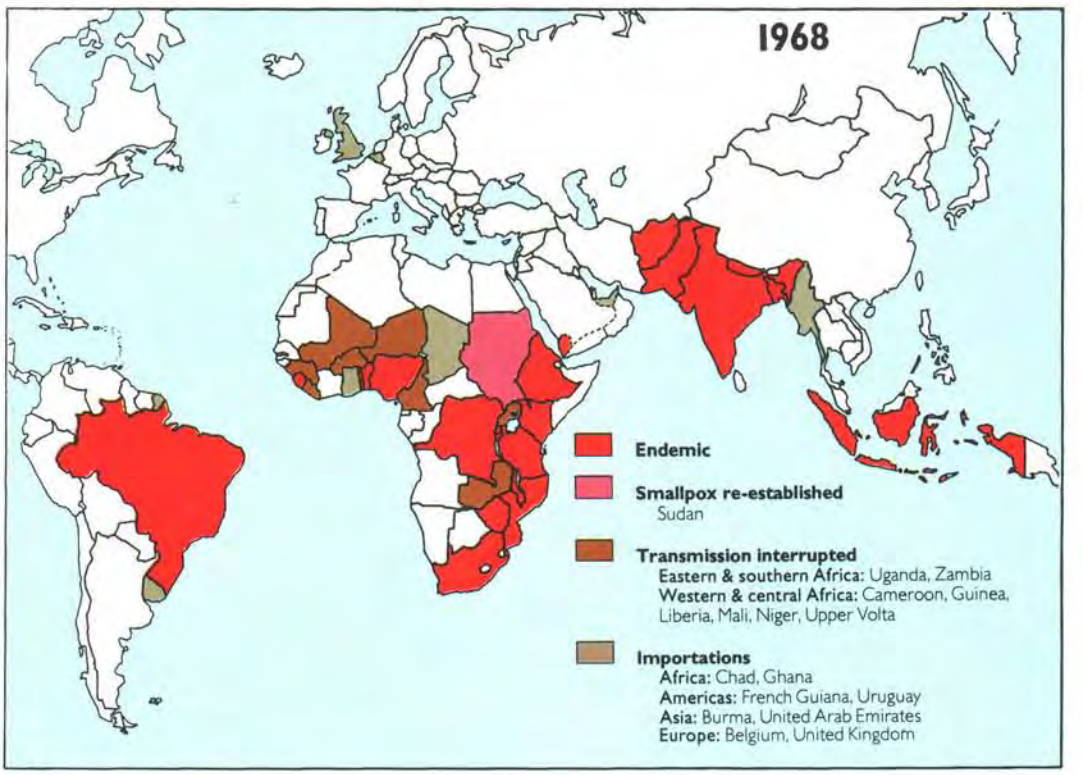
Other developments

The lack of attention to surveillance was a matter of special concern and surveillance was stressed as being "as important as the vaccination programme itself" at the Twenty-first World Health Assembly in May and emphasized again at an intercountry seminar in Kinshasa in November. Special training materials were developed to foster an understanding of the principles and methods involved.

The bifurcated needles, introduced for general use, alleviated some shortages of vaccine, but it became apparent that the endemic countries would soon need to produce much more vaccine. WHO convened experts in vaccine production to develop a manual on production methodology, and the Organization sent consultants to 24 laboratories and provided equipment and reagents to 30.

The dissemination of information about the programme and about field observations was facilitated as reports about the programme began to be published every 2–3 weeks in the *Weekly epidemiological record* from May onwards and other documents were distributed regularly to senior eradication staff throughout the world.

Activities during the first 2 years of the Intensified Programme laid a sound foundation but how this could be built upon in the field was uncertain. Although the progress in western and central Africa was encouraging, the resources made available there by the USA were greater than could then be foreseen for other countries; progress elsewhere was made primarily in the countries with the more advanced health services. At the end of 1968, the feasibility of global smallpox eradication was by no means certain.



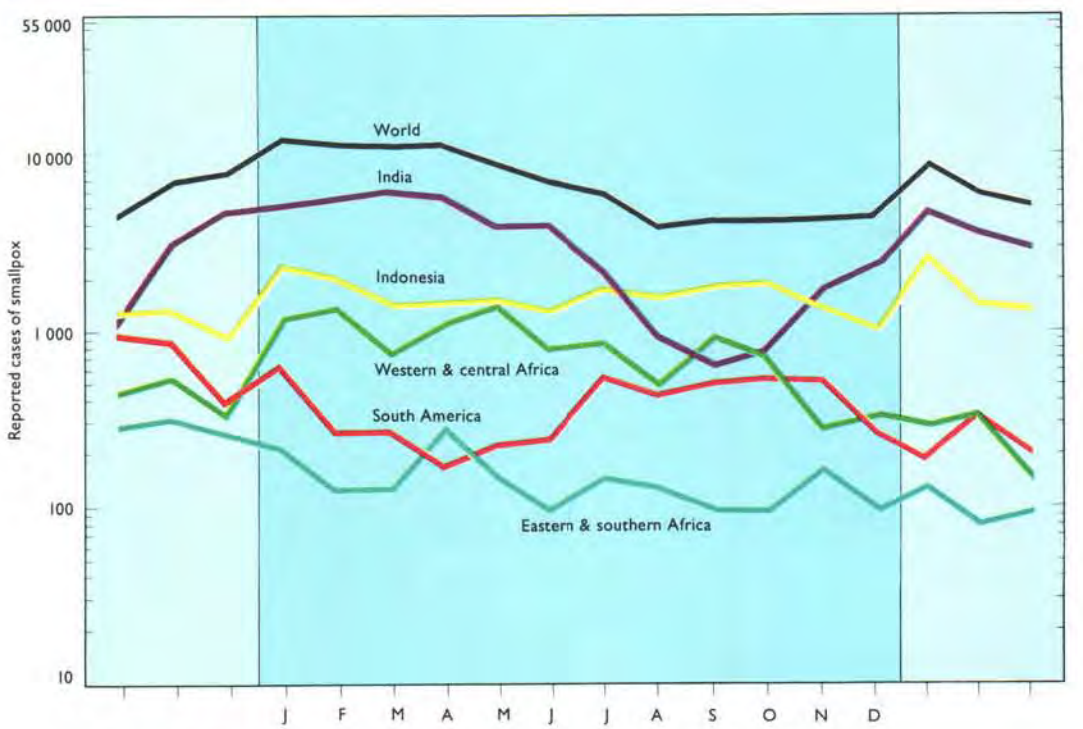


Plate 10.43. Smallpox in the world, 1968.

The Situation in 1969

Certain evidence of progress came during the third year of the Intensified Programme. Only 23 countries recorded endemic cases that year—8 fewer than in 1968—and in 5 of them transmission was interrupted. Thus, during a period of only 3 years, 15 countries successfully eliminated smallpox. Except for Yemen, they were all in Africa, and 10 of them were in western and central Africa where, at the end of 1969, smallpox persisted only in northern Nigeria. Kenya and Mozambique also ceased to report cases but because surveillance was inadequate there, the absence of cases was viewed with scepticism at first.

Although improved notification procedures led to more complete reporting in several countries, the total number of cases reported in the world declined to 54 199, the lowest figure that had ever been recorded. The optimism this gave rise to was tempered, however, by the realization that none of the countries in which transmission had been stopped was large, only Kenya having a population of as many as 10 million persons.

Africa

The successes in Africa were encouraging but 4 of the largest countries still presented serious problems. The programme in the Democratic Republic of the Congo progressed well but the country was one of the largest in Africa, transport presented formidable problems and smallpox was prevalent everywhere. In the Sudan, smallpox spread widely after being imported and civil war throughout its southern provinces made activities impossible there. In November, Ethiopia, which presented the greatest logistic challenge, reluctantly agreed to a programme but it could not begin until 1971. About South Africa, little was then known except that the number of reported smallpox cases increased from 43 in 1967 to 246 in 1969.

South America

Brazil intensified its vaccination campaign and began surveillance programmes in 4 states. Because of this, notifications improved and the number of reported cases increased from 4372 in 1968 to 7407 cases in 1969. Near the end of the year, however, the principal surveillance officers were discharged and the director of the programme resigned.

Asia

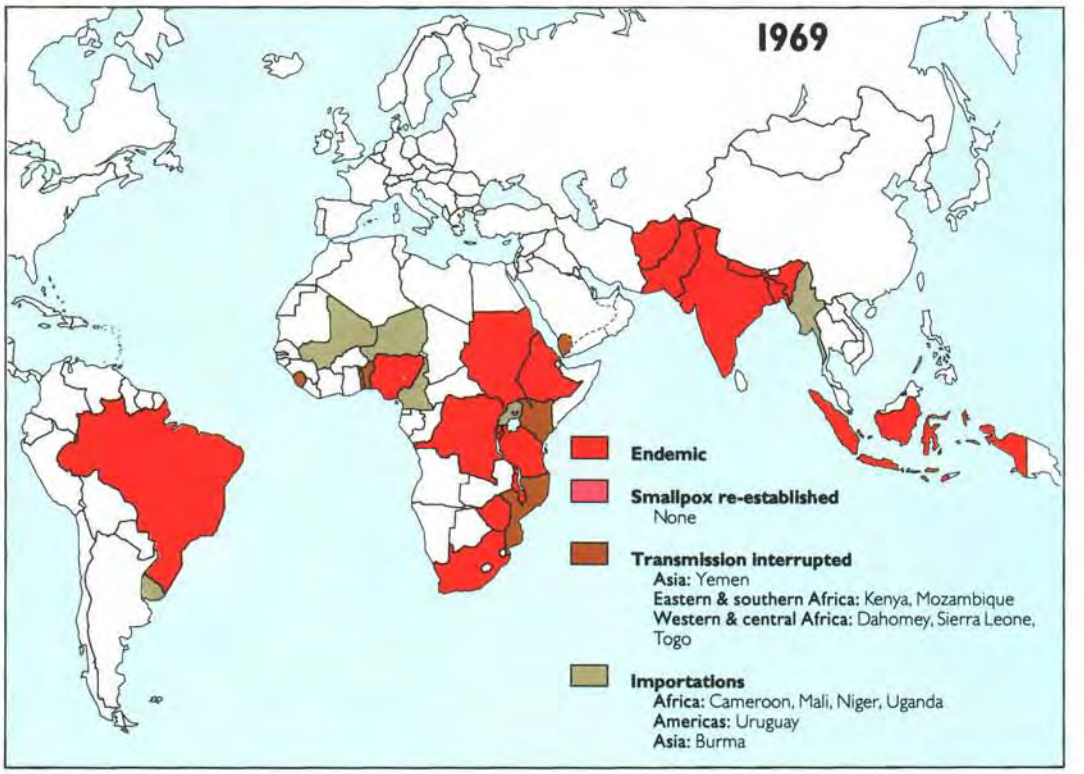
The programmes in Afghanistan, Indonesia and Nepal were substantially strengthened during 1969 but there was little progress to report in either India or Pakistan. Mass vaccination campaigns in East and West Pakistan were far behind schedule and surveillance activities were nominal, at best. India postponed the signing of an agreement to strengthen its programme and, in 1969, reported more births than primary vaccinations. India's decision that year to begin using the bifurcated needle and to terminate the use of liquid vaccine was almost the only encouraging news from a country which each year continued to report one-third to one-half or more of the world's cases of smallpox.

Other developments

Vaccine production increased in a number of the endemic countries in 1969, but shortages could be foreseen as the year progressed and more programmes began. Despite appeals for additional donations of vaccine, the quantities contributed in 1969 were smaller than in 1968.

The attainment of global eradication rested on the premise that there was no animal or other natural reservoir of the virus, but firmer evidence of this was required. In March 1969, the first of a series of biennial meetings of an informal group of research workers was convened by WHO in Moscow to plan and implement a collaborative research programme to discover whether any reservoir of variola virus existed and to elucidate the behaviour of the closely related monkeypox virus.

The promotion of surveillance–containment activities continued to meet with limited success and so the Director-General presented a special report to the WHO Executive Board which recommended for every country the "*immediate investigation of every reported case of smallpox by trained investigators, the tracing of the source of infection and the prompt application of containment measures*". In May, a seminar for the countries of western and central Africa provided important documentation of this approach, and another, held in Pakistan in November, for participants from 11 countries of the Eastern Mediterranean and South-East Asia Regions, stressed its importance. Translation of the methods into practice, however, continued to progress slowly.



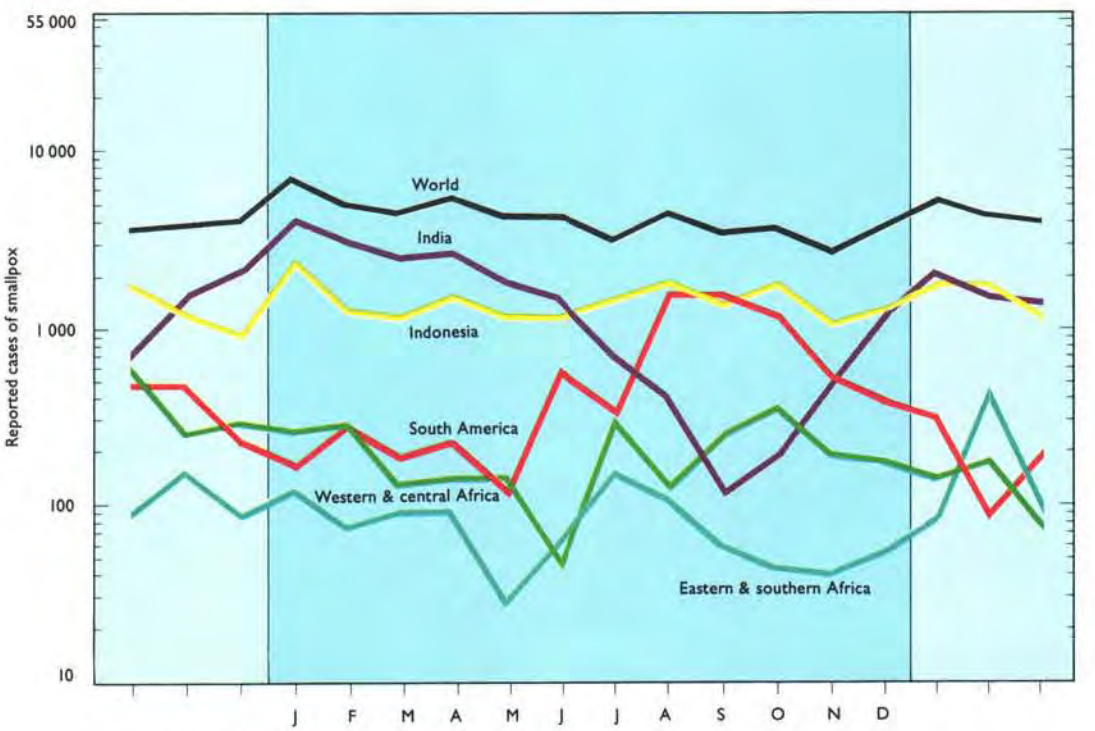


Plate 10.44. Smallpox in the world, 1969.

The Situation in 1970

Developments in 1970 gave grounds for genuine optimism that global smallpox eradication could be achieved: only 18 countries recorded endemic cases during the year and in 6 of these transmission was interrupted—5 in Africa and 1 in Asia. Large populations were involved. With the containment of the last cases in Nigeria in May, more than 100 million persons in western and central Africa were in a smallpox-free region. Wholly unexpected was the elimination of smallpox from the densely populated area of East Pakistan (population in 1970, almost 66 million) following a brief but effective surveillance–containment programme. The reported cases of smallpox in the world during 1970 numbered only 33 693, a decrease of 38% from the record low of the previous year.

Africa

At the end of 1970, smallpox was considered to be endemic in only 5 countries in the whole of Africa: the Democratic Republic of the Congo, Ethiopia, Malawi, South Africa and the Sudan. Excellent progress was made in the Democratic Republic of the Congo during the year and South Africa embarked on a special vaccination campaign. Sudan's programme, however, progressed slowly in the accessible areas and nothing could yet be done in the strife-ridden southern provinces. Ethiopia's programme had not yet started, and the epidemiological situation in Malawi was unclear.

South America

The increased incidence of smallpox reported during 1969 had brought additional resources and support to Brazil's programme; its vaccination campaign accelerated and by the end of 1970 it appeared to be on the verge of interrupting transmission. Programmes in other countries were proceeding adequately and only 1 outbreak was detected, in an Argentinian town on the Brazilian border.

Asia

Indonesia conducted a successful surveillance–containment programme and estimated that by the end of the year 85% of its population resided in smallpox-free areas. Although transmission had been interrupted in East Pakistan and programmes in Afghanistan and Nepal were progressing well, those in India and West Pakistan were not. In West Pakistan, a poorly conducted mass vaccination campaign lagged far behind schedule. India agreed to strengthen its national structure with WHO assistance, but otherwise remained confident as the number of reported cases continued to decrease, only 12 773 cases being reported in 1970 compared with 84 902 cases in 1967. Late in the year, however, it became evident that this was partly an artificial decrease, changes in the national notification system serving to inhibit reporting.

To encourage surveillance–containment activities in Asia, a seminar was held in New Delhi in December 1970 for countries throughout the South-East Asia Region. West African and Indonesian staff described their successes with this strategy but few changes followed.

A significant event, although it was not recognized until a year later, was the reintroduction of endemic smallpox into Iran. Major epidemics were to follow, with spread of the disease to neighbouring countries and eventually to Europe.

Other developments

With more eradication programmes in progress, increasing resources were required. Efforts to obtain additional donations met with little success, and an attempt to have WHO funds that were available in the Americas reallocated for use in Asian countries also failed. Vaccine was short throughout 1970 and donated vaccine frequently had to be dispatched on the very day it was received in Geneva. Towards the end of the year, it became apparent that it would be far more difficult to eradicate smallpox from the remaining endemic countries than it had been in those which had already been freed of the disease.

Another unexpected problem occurred when, in the second half of the year, human cases of monkeypox, clinically indistinguishable from smallpox, were discovered in Liberia, Sierra Leone and Zaire. Although monkeypox was not caused by the variola virus, the question arose whether it might behave like smallpox and be sustained by human-to-human spread. Extensive field and laboratory investigations began immediately but not until the late 1970s could the fears be fully allayed.

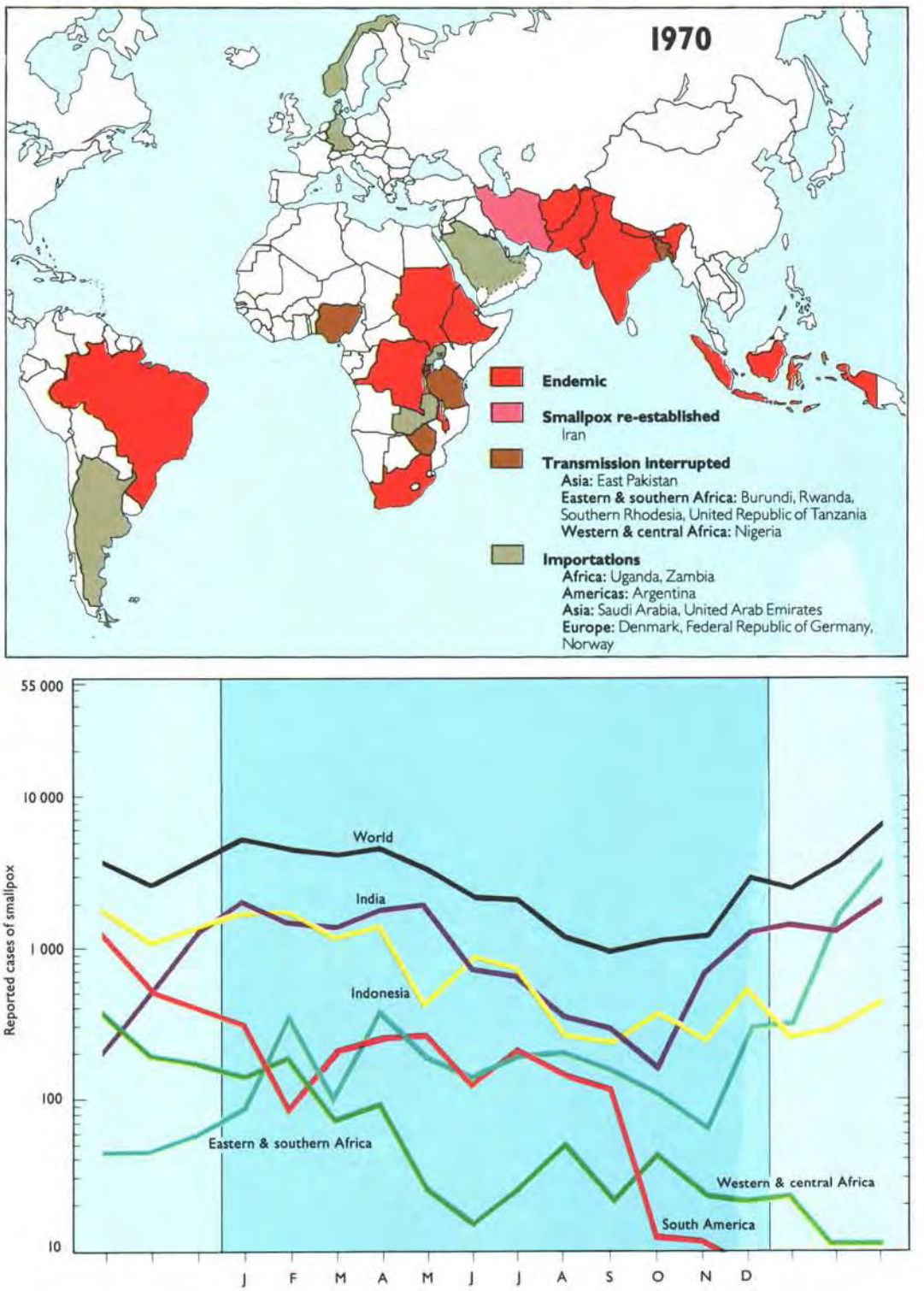


Plate 10.45. Smallpox in the world, 1970.

The Situation in 1971

The fifth and sixth years of the Intensified Programme, 1971 and 1972, were years of transition between the remarkably successful period 1967–1970—when smallpox was successfully eliminated from large areas of the world with few resources—and the succeeding years, 1973–1977, when ever larger resources and more heroic measures were required to stop transmission in the few remaining endemic countries. In some parts of the world remarkable progress was made during 1971, but in others there were setbacks and portents of future problems. The year 1971 began with endemic smallpox in 12 countries, 4 of which interrupted transmission during the year, but 2 others became reinfected—Botswana and Iraq. For the first year since the programme began, the number of reported cases increased, from 33 693 in 1970 to 52 807 in 1971.

Americas

In April, the last cases in Brazil, and in the Western Hemisphere, were detected. Thus, the first of the 4 major epidemiological zones became smallpox-free. A plan of work was immediately developed for investigations and reports that would permit the certification of eradication after 2 years.

Africa

After transmission had been interrupted during the year in Malawi, South Africa and Zaire (formerly the Democratic Republic of the Congo), smallpox was endemic in only 3 African countries at the end of 1971—Ethiopia, the Sudan and Botswana (where it spread widely after having been reintroduced just as the last cases were occurring in South Africa). The programme that started in Ethiopia in 1971 found smallpox to be a far greater problem than had been expected. A staff of fewer than 80 persons detected 26 329 cases, compared with the 722 cases reported in 1970. In the Sudan, smallpox continued unabated in the southern provinces affected by civil war. It was apparent that eradication throughout Africa would need a greatly intensified effort, accompanied by a measure of good fortune, to surmount the problems of civil war.

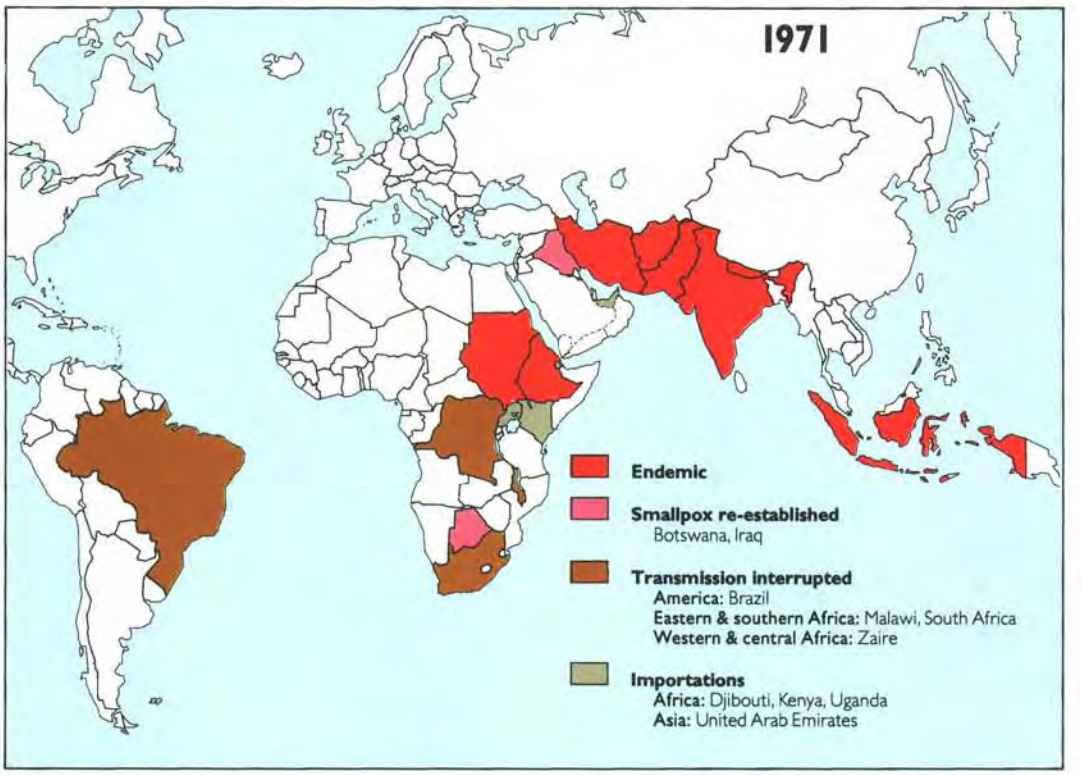
Asia

In Asia, too, both successes and setbacks occurred. The programmes in Afghanistan, Indonesia and Nepal progressed so satisfactorily that, by the end of the year, each appeared to be on the verge of eliminating smallpox. One western state of India (Gujarat), which had been reporting 10% of the world's cases, mounted a highly effective surveillance–containment programme and succeeded in stopping transmission within a year. Epidemic smallpox, however, erupted in adjacent Indian states and, there, satisfactory programmes were slow to begin. During 1971, civil war in smallpox-free East Pakistan (which became Bangladesh in December) caused some 10 million refugees to flee to India, where most of them were housed in special camps in areas in which smallpox was prevalent. Although all persons were supposed to be vaccinated on arrival, this precaution was not taken in several camps, including one of the largest. There, smallpox broke out at the end of the year and spread throughout the camp. In West Pakistan, an unsatisfactory programme was further compromised when the country was divided into 4 largely autonomous provinces and separate programmes had to be re-established in each.

It was in the course of 1971 that the presence of smallpox in Iran first became known through numerous unofficial reports, and the government eventually acknowledged that 29 cases had occurred, all of which were said to have been importations. Much later, it was learned that smallpox had in fact been introduced from Afghanistan in October 1970 and that hundreds of cases had occurred in 1971. Subsequently, it was discovered that the disease had also spread to Iraq in November 1971.

Other developments

Sufficient progress had been made in eradication to cause the authorities in both the United Kingdom and the USA to cease their programmes of routine vaccination in 1971. However, a WHO Expert Committee on Smallpox Eradication, convened in November, presciently observed that "an effort at least equal to that made in the past 5 years" would be required to interrupt transmission in the remaining endemic areas. Although few countries were now involved, they posed difficult problems. To encourage national governments and their smallpox personnel, the WHO Headquarters staff began to spend an increasing amount of time in the field, but additional resources were not forthcoming and vaccine remained in critically short supply.



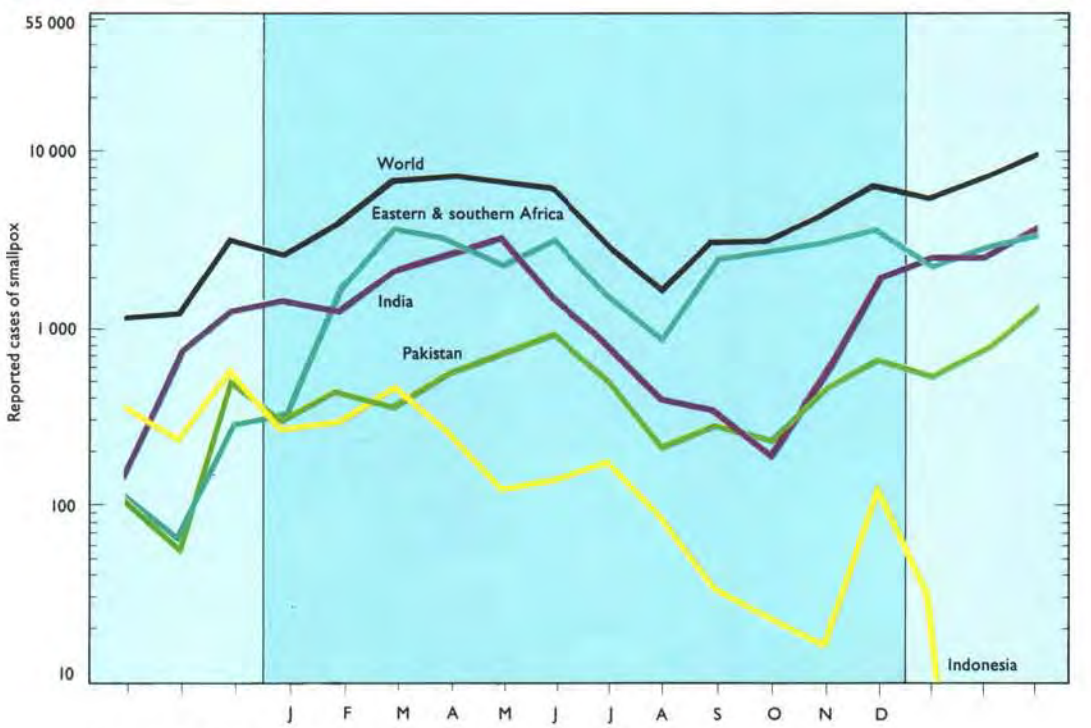


Plate 10.46. Smallpox in the world, 1971: eradication from Brazil.

The Situation in 1972

Like the preceding year, 1972 was marked by notable successes and unexpected setbacks. Overall, the progress was encouraging. There were 10 endemic countries as the year began, but transmission was stopped in 5 of them in the course of the year. Successes in 3 of these—Afghanistan, Indonesia and the Sudan—represented exceptional achievements. The other 2 were Iran and Iraq, for which the true situation was not known with certainty until a year later. The number of cases of smallpox recorded in the world as a whole increased for the second successive year—65 140 cases in 1972 compared with 52 807 cases in 1971—but reporting was more complete and, by the summer, surveillance programmes of some sort were in place for the first time in all countries.

During the first quarter of the year, however, 3 serious problems emerged. In February, epidemics of smallpox began to spread across the newly independent country of Bangladesh as refugees returning from camps in India brought the infection with them. In March, Iraq and the Syrian Arab Republic officially acknowledged the presence of smallpox and soon thereafter a major outbreak occurred in Yugoslavia, imported from Iraq. Finally, in April, a WHO epidemiologist, on arrival in Botswana, confirmed that smallpox had already spread widely there.

Despite these problems, the geographical extent of the infected areas continued to diminish and it was proposed that "the final phase" should begin in September, the objective being a nil incidence by June 1974. Intercountry seminars were held in Ethiopia (September), India (November) and Pakistan (November) to launch this special effort, referred to for the first time as "Target Zero" in an issue of the WHO magazine *World health* and in the first of a series of fortnightly reports circulated by the WHO Smallpox Eradication unit.

Africa

The progress in 1972 in the 3 endemic African countries exceeded expectations. In the Sudan, the civil war in the southern provinces ceased and an effective surveillance–containment programme succeeded in interrupting transmission in December, more than a year earlier than WHO staff had expected. Botswana rapidly mobilized its resources and by the end of the year the interruption of transmission seemed imminent. As Ethiopia's programme gained momentum, the number of reported cases decreased by 35%, from 26 329 in 1971 to 16 999.

Asia

The second of the world's major epidemiological zones became free of smallpox in January, when transmission ceased in Indonesia. This was achieved in less than 4 years and with only a modest amount of international assistance. Afghanistan, where formidable geographical and cultural problems were compounded by the practice of variolation, had once been thought the country in which attempts to eradicate smallpox were the least likely to succeed. Yet it recorded its last endemic cases in October. These successes provided some much-needed encouragement to the other endemic countries of Asia, whose situation was very different. Emergency assistance had been promptly provided to Bangladesh to stem the epidemic of imported cases but, in the post-war chaos, the health services were unable to cope. More than 10 000 cases were recorded, but it is estimated from later studies that more than 100 000 cases occurred. During the autumn, major epidemics began along the densely populated Indo-Gangetic plain in southern Pakistan, India and central and western Bangladesh. Because of the very large numbers of health staff in the Asian countries and the greater interest in eradication taken by the national authorities, hope remained high that the problems might yet be surmounted, but far more serious difficulties were to develop.

Other developments

An epidemic in Yugoslavia, the first in that country for 41 years and one of the largest in Europe since the Second World War, reminded donor countries of the severity of the disease and emphasized the importance of global smallpox eradication. Increased donations of vaccine were received and the debate at the Twenty-fifth World Health Assembly was the most extensive ever, praise for the achievements being mingled with expressions of concern about setbacks in Bangladesh, Botswana and western Asia. Despite the sentiments expressed, however, voluntary financial contributions remained at much the same level as before and WHO even decreased its regular budget allocation for the programme for the following year.

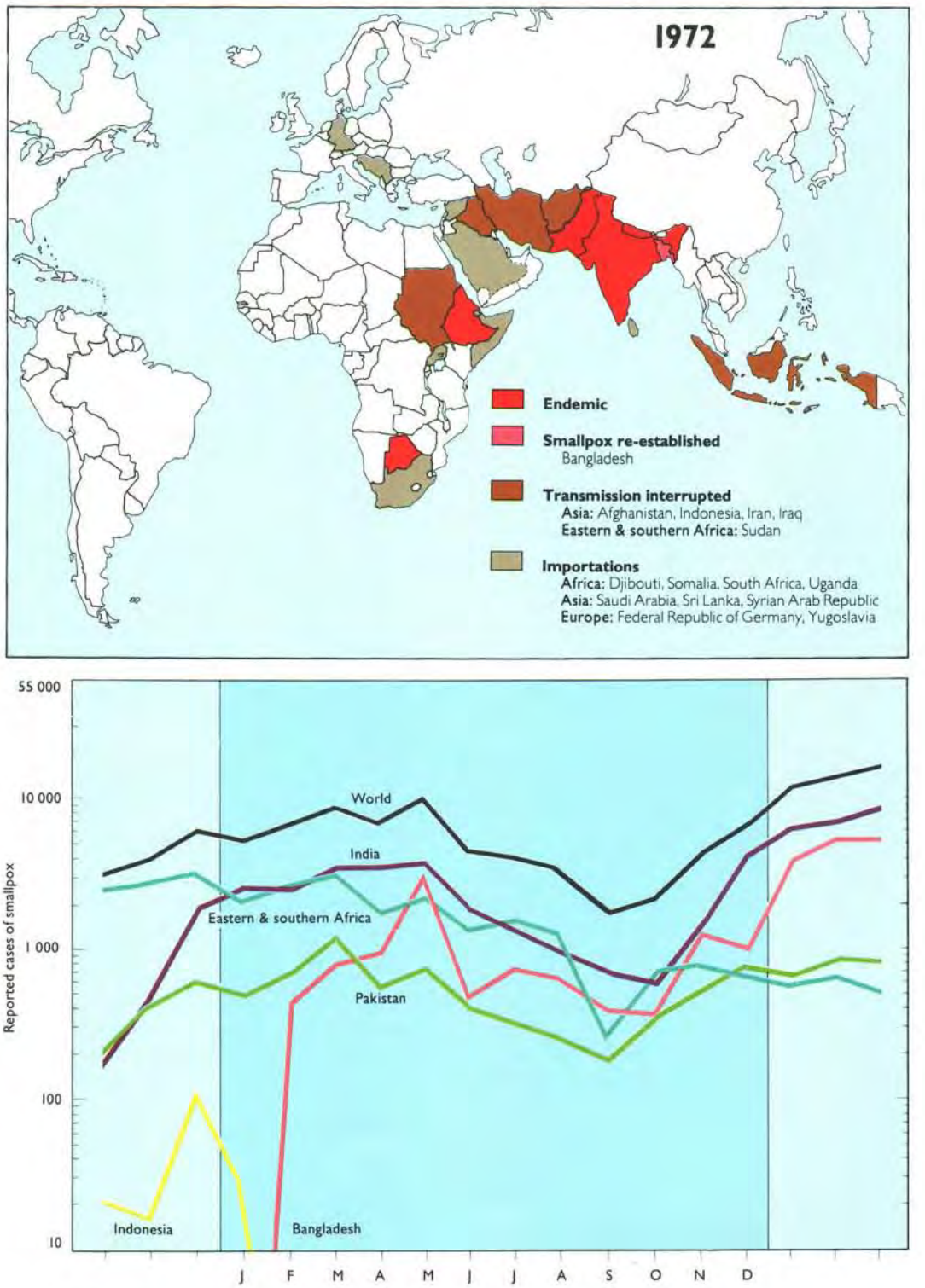


Plate 10.47. Smallpox in the world, 1972: eradication from Indonesia.

The Situation in 1973

The year 1973 marked the beginning of a greatly intensified effort, which steadily increased in tempo from the autumn. As the year began, only 6 endemic countries remained. Among these, Botswana recorded only 27 cases before successfully stopping transmission in November and Nepal reported 277 cases, almost all of which could be shown to have occurred following importations from India. Although the other 4 countries (Bangladesh, Ethiopia, India and Pakistan) reported large numbers of cases, large areas within each of them were free of smallpox or nearly so. It was calculated that 90% of all cases in 1973 occurred over only 10% of the land area of the 4 countries.

Asia

During the first 6 months of the year, the number of cases reported in Asia rose sharply. Although some of this increase was thought to represent more complete notification of cases, surveillance was still by no means fully satisfactory anywhere and epidemics were being discovered of a size not seen since the beginning of the Intensified Programme. By the end of June, almost 83 000 cases had been reported, including some 49 000 in India, 27 000 in Bangladesh and 6000 in Pakistan—totals which were all higher than during the comparable period in 1972.

For these countries, it appeared that a different strategy would be required to eliminate smallpox. The comparatively simple measures for case detection and containment which had previously been effective in Africa were proving inadequate in Asia. The solution proposed was to detect cases more promptly so that they could be contained before further spread occurred. In July, therefore, Indian and WHO staff decided to mobilize all health staff in India to undertake 1-week, village-by-village searches in October, November and December in the 4 states which were then reporting 93% of all cases. In other Indian states 1 or 2 searches would be conducted during this 3-month period. A similar effort was decided upon in Pakistan. The hope was to eliminate most smallpox foci during the autumn, when smallpox spread slowly, and thus to prevent widespread dissemination during the period of rapid transmission from January to April. If this was successful, it was believed that smallpox could be eliminated during the summer of 1974. In Bangladesh, many additional surveillance teams were provided to search for smallpox in schools and markets.

The results were encouraging in Bangladesh and Pakistan, each country reporting an incidence similar to that of the year before despite much more intensive surveillance. In India, however, more than 30 000 cases were discovered between October and December, almost 5 times as many as had been found during the same period in 1972 and, indeed, more cases than had been reported in the whole country during any of the 4 preceding years. The numbers were scarcely believable but the eradication programme staff continued to be optimistic because of the commitment of government officials, the extent of activity and the interest of the health staffs.

Africa

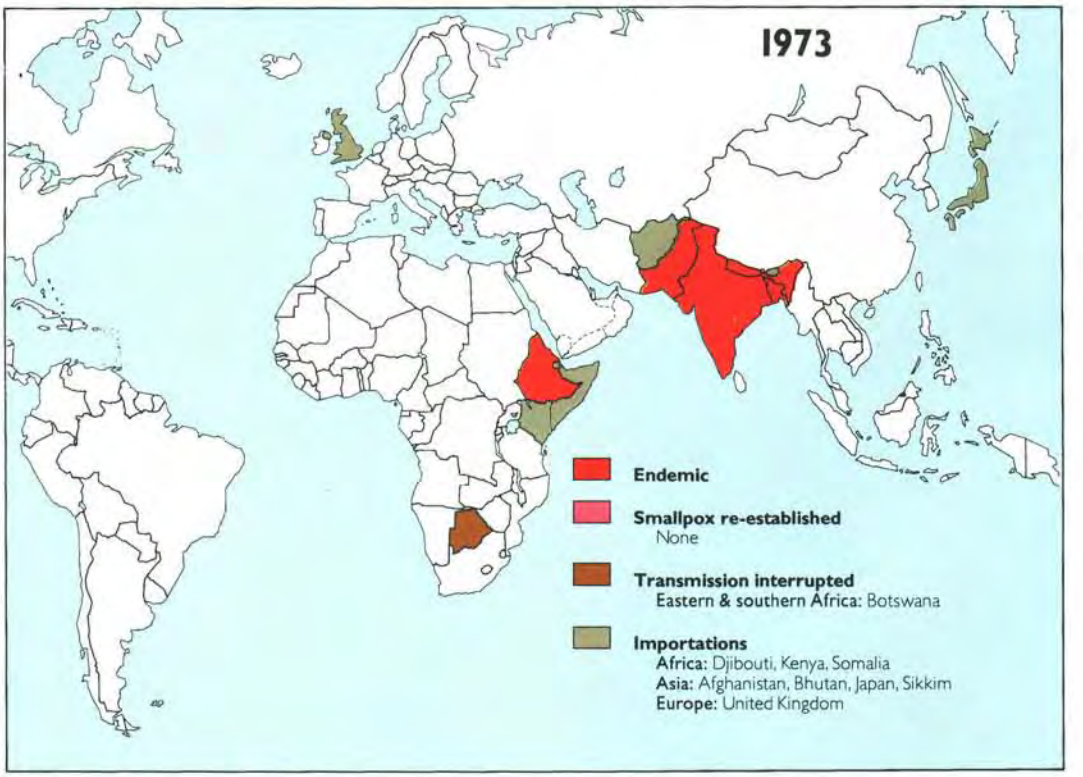
Ethiopia remained the only endemic country in Africa and there, as in Asia, more intensive measures were taken through the addition of staff and the provision of helicopters to help cope with the rugged terrain. The number of reported cases continued to decline despite more complete notifications but logistic difficulties were increasingly exacerbated by mounting civil unrest.

Other developments

During 1973, the first of the international commissions for the certification of eradication examined the programmes in the Americas and confirmed that smallpox had been eradicated from the Western Hemisphere.

A new concern emerged, however, about a possible natural reservoir of smallpox. This arose from the isolation—from monkey kidney tissue cell cultures in the Netherlands and from animal specimens collected near monkeypox cases in Zaire—of what were termed "whitepox" viruses, which were indistinguishable from smallpox virus. The WHO informal research group held its third biennial meeting in 1973 and developed a new agenda of work, but not for several years was this concern finally laid to rest and the "whitepox" viruses shown to be inadvertent laboratory contaminants.

During 1973, the number of recorded cases in the world—135 904—was the highest for 15 years, but the ultimate goal, "Target Zero", appeared none the less to be just over the horizon.



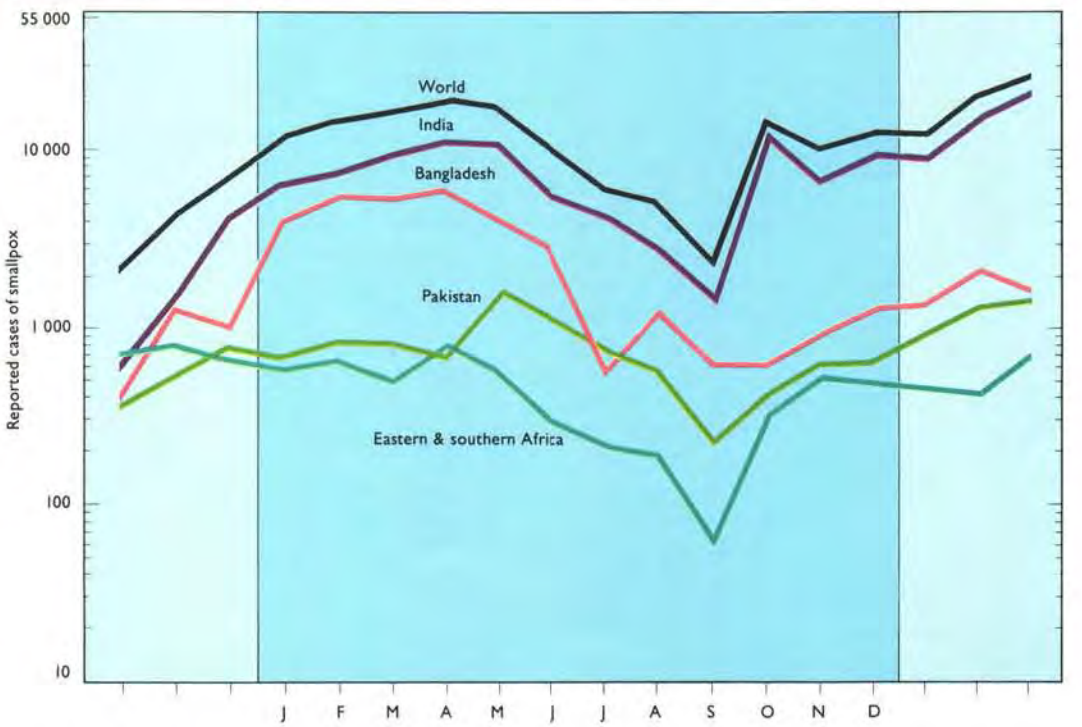


Plate 10.48. Smallpox in the world, 1973.

The Situation in 1974

Throughout 1974, the programme as a whole steadily grew in intensity and accelerated in tempo. Successes in the 1973 autumn campaigns had encouraged the belief that a concerted effort of no more than 6–12 months would see the realization of global smallpox eradication. Additional national and international personnel as well as increased quantities of supplies and equipment supported this effort. It was concentrated on the shrinking endemic areas which in aggregate were smaller than the land area of Pakistan, one of the 5 countries concerned. With eradication apparently imminent, programme staff worked feverishly, driven partly by the fear that unanticipated natural or man-made catastrophes might thwart the achievement just short of the goal. Indeed, this concern proved well founded in 4 of the 5 countries.

Asia

In India, during the first 3 months of the year, intensified search programmes resulted in much more complete reporting but no more cases than in 1973. In May, however, explosive epidemics began, nearly 50 000 cases being detected that month and the worst affected state (Bihar) reporting more than 8000 cases in a week. Work was severely hampered by petrol shortages as well as by strikes which immobilized rail and air transport. Bihar State was further affected by devastating floods in the north, severe drought in the south, and civil disorder. These difficulties were compounded by a major epidemic in an urban industrial centre which resulted in the spread of smallpox to hundreds of distant villages in India and Nepal.

In Pakistan and Bangladesh, other problems occurred. Surveillance in Pakistan's largest province (Punjab) was suspended prematurely by over-optimistic provincial health authorities and an undetected epidemic in its capital, Lahore, quickly spread throughout the province. Bangladesh decided to restructure the health care system, resulting in the suspension of most activities, including those for smallpox, for many weeks. In the summer, monsoon rains brought the worst floods for many years to northern Bangladesh, displacing tens of thousands of persons.

During the first 6 months of 1974, more cases were recorded in Asia than had been reported annually throughout the world for more than 15 years. By June, however, greatly expanded and better organized programmes were functioning and progress began to be measured in terms of the numbers of existing outbreaks (villages or town areas in which 1 case or more had occurred in the preceding 4 weeks). Asia had 8086 outbreaks in June.

Throughout the hot summer monsoon period, all staff were urged to maintain the pace of their work in order to take the fullest advantage of the seasonal decline in incidence. The effort proved successful. Pakistan detected its last case in November, and by the end of the year there were only 517 known outbreaks in all of Asia.

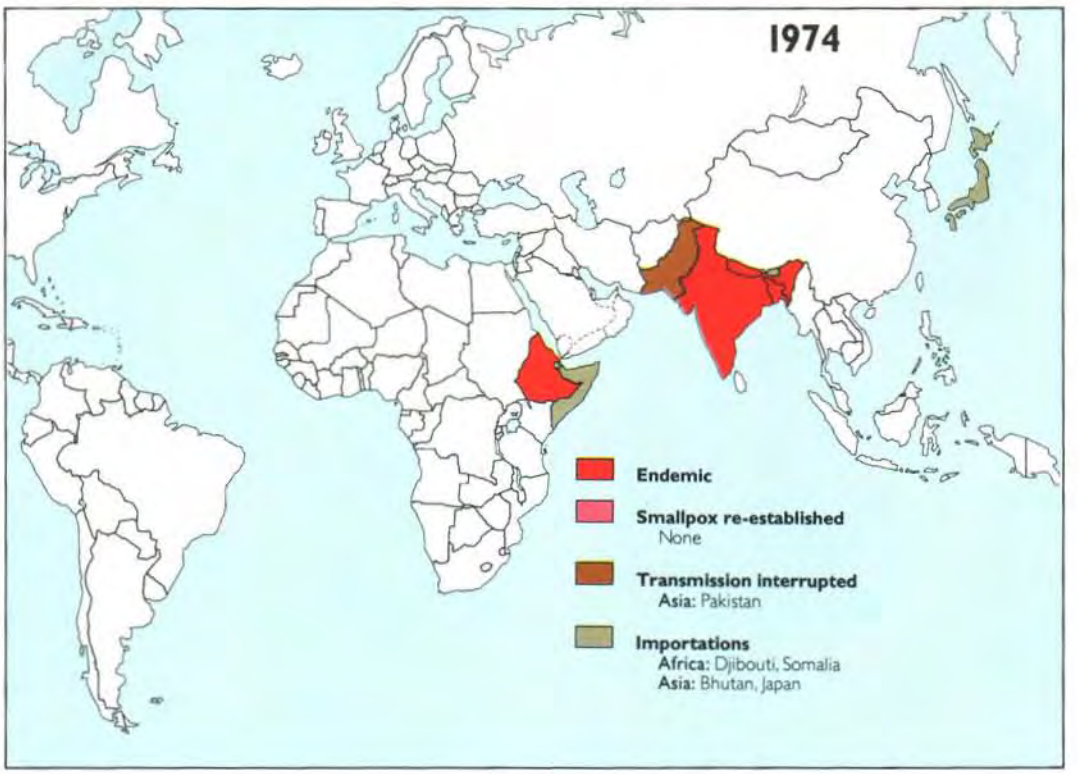
There was optimism that transmission would be interrupted by the summer of 1975. The only doubtful areas were those in which refugees were crowded in Bangladesh. The number of outbreaks in that country, which had been only 78 at the end of October, had tripled by the end of December. More than half, however, consisted of only 1 or 2 cases and hope persisted that, with the planned addition of health staff and temporary workers, the problem could be managed.

Africa

As more support became available, the programme in Ethiopia made steady progress in many areas of the country. The number of reported cases decreased from 5414 in 1973 to 4439 despite more complete notifications; in December, only 166 cases were discovered. In increasingly large areas of the country, however, field operations were severely hampered by the revolution that led to the deposition of the Emperor, by hostilities with Somalia in the Ogaden desert, and by the insurrection in Eritrea.

Other developments

The eradication of smallpox from Indonesia was certified by an international commission in April, but certification elsewhere was deferred pending further progress in Africa and Asia. Increasing efforts were made to recruit suitable international staff and consultants for the intensified campaign and to obtain sufficient contributions of vaccine and funds to permit the work to be sustained. At the end of the year WHO, for the first time, convened a meeting of potential donors to request contributions of US$3.3 million, but only US$2.1 million were pledged.



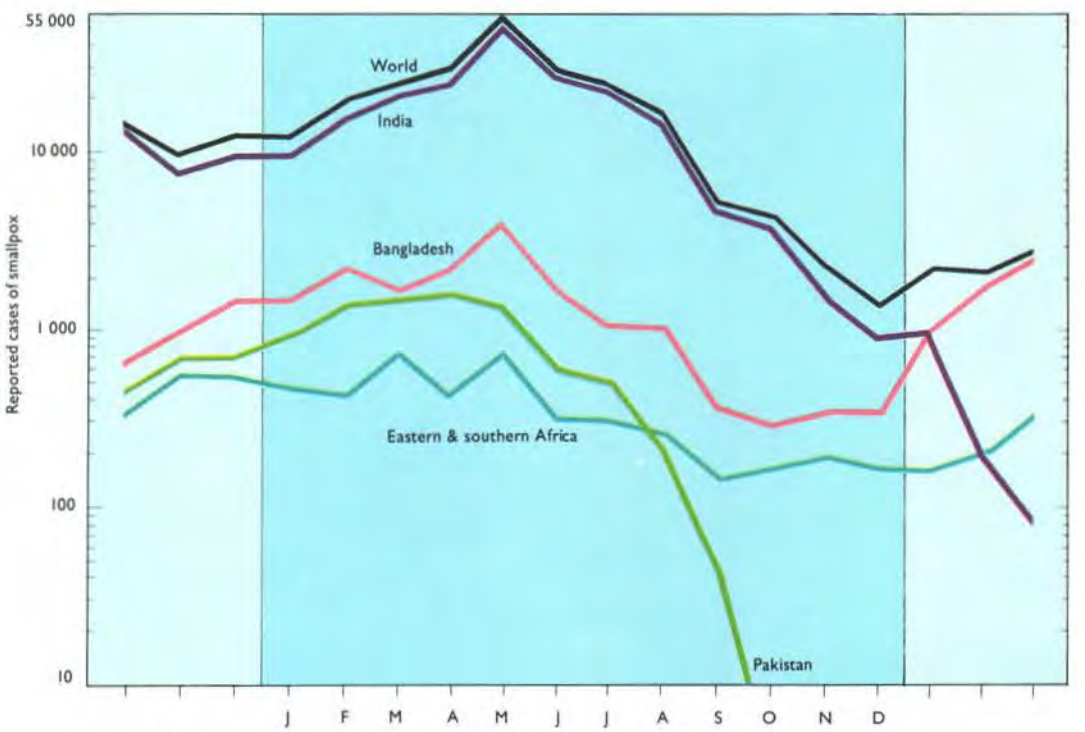


Plate 10.49. Smallpox in the world, 1974.

The Situation in 1975

In 1975, the eradication of smallpox from Asia was achieved and, with it, the end of transmission of variola major virus, which caused the most severe form of smallpox. By the end of the year, endemic smallpox persisted only in Ethiopia, which had 66 known outbreaks, all of which were of variola minor, the mild form of smallpox.

Asia

In India and Nepal, the incidence of smallpox and the number of outbreaks decreased steadily. Nepal detected its last case in April and India in May. Bangladesh, however, was the site of yet another catastrophe as smallpox spread rapidly among the hundreds of thousands of persons displaced by floods and famine and from them to settled populations. Despite heroic efforts, the number of outbreaks increased from 78 in October 1974 to 1280 in mid-May 1975. India strengthened activities in border areas and quickly contained the 32 importations that occurred. Emergency funds made available by Sweden and several other countries permitted the recruitment of additional international staff for Bangladesh, and national mobilization by the Bangladeshi authorities resulted in 12 000 persons being fully engaged in eradication work. From May to August, the incidence in Bangladesh diminished rapidly but work had to be partially suspended in August, when the President of the country was assassinated. Officials feared civil war and yet another mass exodus of refugees. Fortunately, the country remained calm, smallpox eradication activities could be resumed, and on 16 October 1975 the last case occurred.

Africa

In Ethiopia, it had been expected that the eradication of smallpox would follow the same pattern as in other African countries, with transmission being interrupted 2–3 years after the programme began. By 1975, however, the Ethiopian programme had been in operation for 4 years and although the staff were few in number, they were capable and strongly motivated. Surveillance–containment activities had been conducted since the start of the programme and more than 10 million persons had been vaccinated—nearly half of Ethiopia's estimated population. Although the population density was low and the habitations widely scattered, the mild variola minor continued to spread. The principal problem area was the rugged highland plateau, where resistance to vaccination was great and where large areas were periodically inaccessible owing to civil war. As a result of the eradication of smallpox from Asia, additional resources could be provided, permitting a 5-fold increase in staff, but the hostilities within the country hampered their efforts.

Other developments

Rumours of cases of suspected smallpox began to be received with considerable frequency from countries considered to be free of the disease. Even though they proved false, arrangements had to be made to investigate each rumour thoroughly and to publicize the findings in order to maintain confidence in eradication. Another emerging problem was that of designing and implementing an appropriate strategy to permit eradication to be certified in the African countries, some of which had detected no smallpox for many years and had consequently stopped their smallpox eradication activities. Certification of eradication in Africa had been deferred until the continent as a whole had become smallpox-free. In 1975, however, it was decided that because of the continent's vast size, the large number of countries, and the diminishing level of smallpox eradication activities, preparations for certification should commence as soon as possible. In February, the first of a number of planning meetings was held, this one being concerned with methods for certification in western and central Africa. This implied that eradication in Africa would be achieved, if not within the year, at least soon thereafter. At the end of 1975, however, that was by no means certain.

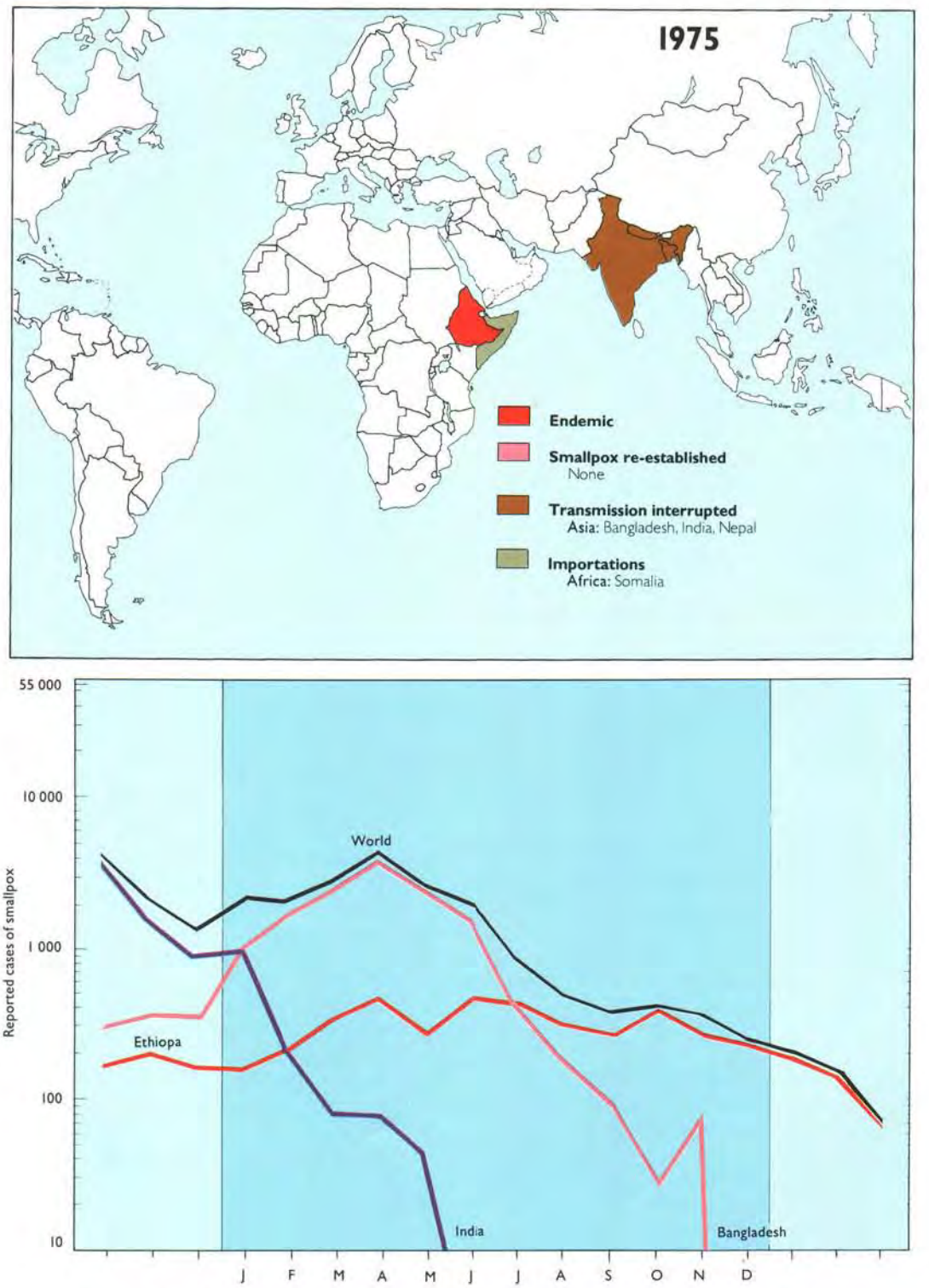


Plate 10.50. Smallpox in the world, 1975: eradication from continental Asia.

The Achievement of Global Eradication, 1976–1977

As 1976 began, smallpox was known to exist in only 66 villages in Ethiopia but the interruption of transmission there and in Somalia, where it became re-established later that year, proved to be as difficult as it had been in mainland Asian countries in 1974–1975. Not until October 1977 was smallpox finally eradicated. A broad range of problems hampered the effort, from difficulties of topography and transport, civil war and eventually war between Ethiopia and Somalia, socio-cultural problems posed by nomads, variolators and large groups who resisted vaccination, to the suppression of reports of cases by the authorities in Somalia.

Ethiopia

Through mid-1976, the resources in Ethiopia were concentrated in the central and northern highland plateau areas in which civil war was raging and most outbreaks were occurring. At great personal risk to the staff concerned, these were gradually contained. Smaller numbers of staff worked in the sparsely settled south-eastern desert, where the few outbreaks occurred primarily among nomads. From past experience in similar areas of western Africa, it had been assumed, erroneously, that smallpox transmission could not long persist in such a scattered, mobile population. In the Ethiopian Ogaden desert, however, variola minor proved to be remarkably tenacious, and operations were frequently interrupted by warfare, the kidnapping of teams and the destruction of vehicles and helicopters. In August 1976, however, the last known outbreak in Ethiopia was contained and, for 7 weeks, no cases were reported from anywhere in the world.

Somalia

From 1972 until February 1976, Somalia had regularly reported importations from Ethiopia, but each was said to have been promptly detected. Late in September 1976, Somalia again reported several imported cases, this time in Mogadishu, the capital. It was learnt later, however, that these were but a few of many cases which were known to the authorities. WHO staff and consultants were quickly sent to help but they were not permitted to visit patients' houses or to travel outside the capital. Repeated mass vaccination campaigns throughout the city failed to stop the spread of smallpox and fully 6 months elapsed before an effective national programme could be established. By then, the disease had spread widely throughout southern Somalia. A large-scale emergency effort was mounted that started in March 1977 and involved adjacent areas of Djibouti, Ethiopia and Kenya. More than 3000 cases were documented before the last case occurred on 26 October 1977.

Other developments

During 1976–1977, certification activities were organized in Asian and African countries, often requiring special studies lasting a year or more before a WHO international commission could be invited to assess the programme and to certify eradication. In April 1976 eradication was certified in 14 countries of western and central Africa, and in December in Afghanistan and Pakistan; in April 1977 in Bhutan, India and Nepal, in June in 9 countries of central Africa, and in December in Bangladesh and Burma.

It became apparent in 1977 that an independent body would be needed to advise on the measures that should be taken to give health authorities throughout the world sufficient confidence in global eradication to be willing to cease vaccination. A group of international experts, which was convened by WHO in October 1977, recommended a number of measures, including the designation by the Director-General of a Global Commission for the Certification of Smallpox Eradication. The Commission was to provide continuing guidance and oversight to the certification process and to report to the Director-General when it was satisfied that global eradication had been achieved.

The question of what should be done about the stocks of variola virus retained in laboratories around the world had long been a troublesome one. The destruction of most, if not all, such stocks was desirable but this required the full cooperation of national governments and of the laboratories concerned. As a first step, a register of the laboratories that held variola virus was prepared. Then, in 1977, the World Health Assembly requested that all variola virus stocks should be destroyed, excepting those held by WHO collaborating centres with maximum containment facilities. Many laboratories soon complied and events in 1978 served to speed the process.

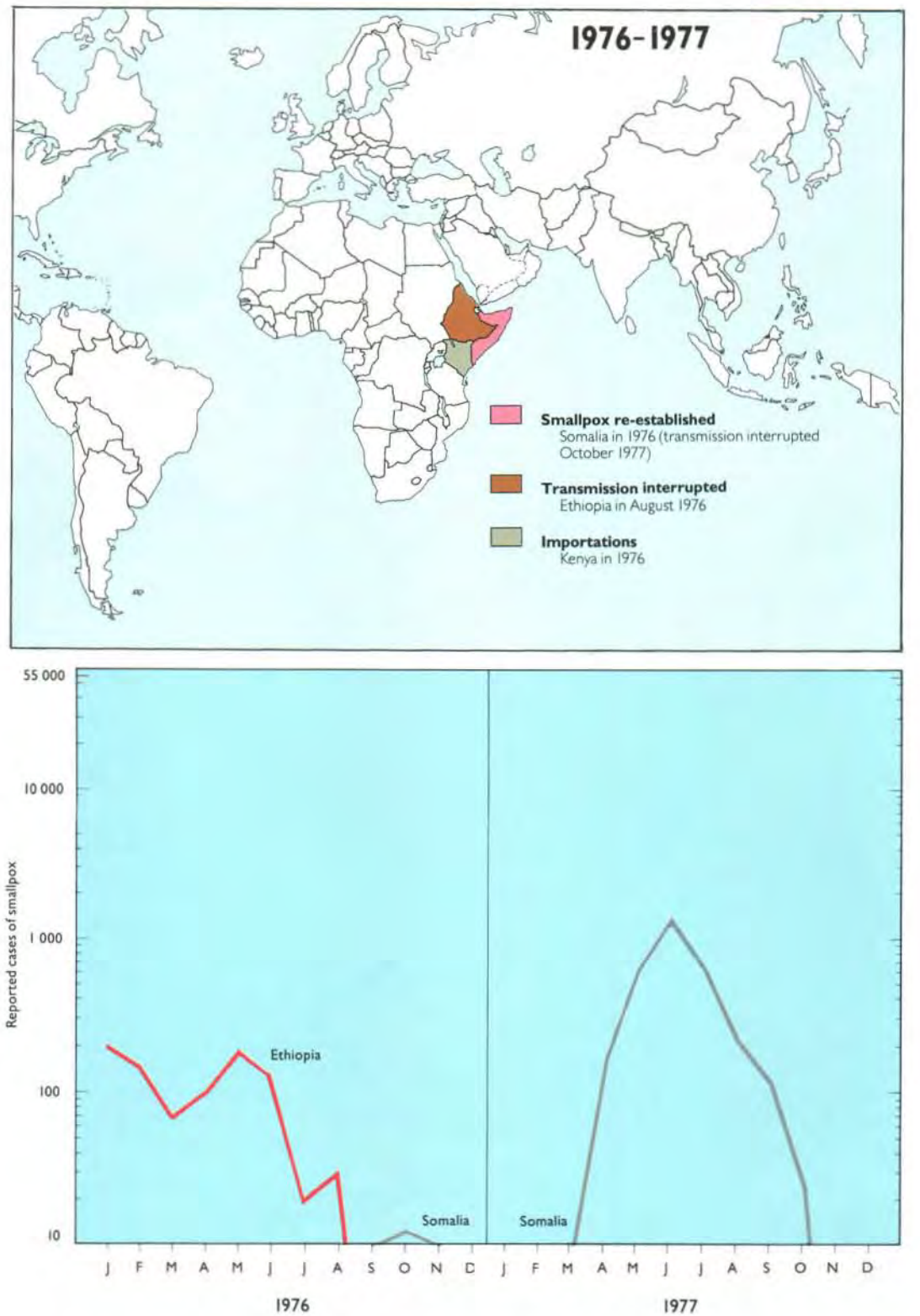


Plate 10.51. Smallpox in the world, 1976-1977: global eradication.

The Certification and Formal Declaration of Global Eradication, 1978–1980

The period between the containment of the last known outbreak and agreement by the Thirty-third World Health Assembly (1980) that global eradication had been achieved was as important but as difficult as had been the preceding years. The world community had to be confident of the attainment of eradication and had to know of the measures which had been taken to certify this. Laboratories had to be persuaded of the need to destroy their stocks of variola virus or to transfer them to WHO collaborating centres. Rumours of possible cases of smallpox had to be investigated and the findings publicized. Research was required to determine the nature of the viruses resembling variola virus which appeared to have been recovered from animals. An assessment of the risk of monkeypox to those living in the tropical rain forests was required as well as a determination of whether that virus could persist by human-to-human spread. Provision also had to be made for the long-term storage of vaccine reserves and for the preservation of records.

However important and substantial the activities which remained, the disappearance of smallpox quickly resulted in a diminished interest in the programme. Only with difficulty were national governments persuaded of the need to assign resources for certification activities, and WHO's budget for smallpox decreased sharply. Remarkably, however, a rigorously scheduled array of activities was completed almost as planned.

During 1978, certification activities were completed in 19 countries, including most of those in southern Africa and western Asia. This brought to 64 the total of countries where eradication had been certified by international commissions. In December, the Global Commission decided that special activities were needed in 15 additional countries. It also recommended that an official attestation be sought from all other countries to the effect that the country concerned had been free of smallpox for at least 2 years. Difficult diplomatic relationships, national sensitivities, civil disturbances and inertia caused serious problems in implementing the recommendations, but one by one the problems were overcome. On 9 December 1979, the Global Commission concluded that the global eradication of smallpox had been achieved and approved a report that was presented to the Thirty-third World Health Assembly in May 1980.

The urgency for laboratories to destroy or transfer their stocks of variola virus became apparent when, in August 1978, 2 cases of smallpox with 1 death occurred as a result of a laboratory infection in Birmingham, England. National authorities took a greater interest in ensuring the safety of their own populations and the number of laboratories retaining stocks of variola virus decreased to 6 by May 1980, and eventually to 2.

In 1978, WHO announced a reward of US$1000 for the report of any new case which could be confirmed as smallpox, and some 50 rumours a year were evaluated in 1978 and 1979 by field investigation and laboratory study. Most proved to be chickenpox; none was a case of smallpox.

Collaborative research on monkeypox and the "whitepox" viruses, conducted in laboratories in Japan, the United Kingdom, the USA and the USSR, revealed the troublesome "whitepox" viruses to have been laboratory contaminants. Field and laboratory studies of monkeypox virus provided increasing evidence that human infections were infrequent and that human-to-human transmission seldom occurred.

Reserves of smallpox vaccine were established and a protocol was developed for the periodic testing of samples to ensure their continuing potency.

Throughout this period, a special public information effort was undertaken to make widely known what had been accomplished and how, so that when the World Health Assembly agreed that eradication had been achieved, the general public would accept the fact more readily.

The declaration on 8 May 1980 by the Thirty-third World Health Assembly that smallpox eradication had been achieved concluded an historic chapter in medicine. Twenty-two years had elapsed since the USSR had first proposed to the Health Assembly that global smallpox eradication should be undertaken, and 14 years since the Assembly had committed special funds to a programme which it hoped would interrupt transmission within 10 years. In fact, 10 years, 9 months and 26 days elapsed from the beginning of the Intensified Smallpox Eradication Programme until the last case in Somalia.