

CHAPTER 18

ZAIRE AND SUDAN

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INTRODUCTION

Eradication programmes in a group of contiguous countries of western and west-central Africa began in 1967 and 1968, with support primarily from the USA and technical assistance provided by the United States Communicable Disease Center. East of this area lay two of Africa's largest countries—Zaire and the Sudan (Fig. 18.1). (Zaire was named the Democratic Republic of the Congo from 1960 to 1971, but its present name is used throughout this chapter for convenience.) Their combined population in 1967 amounted to only about 33 million, but their total area (approximately 4.85 million square kilometres) was equivalent to that of the whole of Europe, excluding the European part of the USSR. Transport and communica-

tions in both countries were poor and the terrain was difficult. Zaire was in WHO's African Region and the Sudan in its Eastern Mediterranean Region.

In the African Region, Zaire strategically had the highest priority for the allocation of WHO resources. Smallpox was endemic throughout the country; in 1967, it accounted for one-third of the total number of cases reported in the countries of central, eastern and southern Africa. Indeed, of all the African countries, only Ethiopia was to record more cases after the Intensified Smallpox Eradication Programme began. Vaccinal immunity was low throughout the country. Along its lengthy western, northern and southern borders lay 5 countries which had interrupted smallpox transmission or seemed close to doing so—Angola, the Central African Re-



Fig. 18.1. Sudan and Zaire and adjacent countries.

public, the Congo, the Sudan and Zambia. In all, these 5 countries reported 686 cases in 1965 and only 66 in 1966. Because of the frequent movement of travellers across the Zairian border, importations of smallpox were inevitable. When they occurred, the detection and control of the outbreaks, especially in border areas, were problematic owing to the paucity of health services and the difficulties of travel and communication.

The status of smallpox in the Sudan was entirely different. A mass vaccination campaign using freeze-dried vaccine had been conducted throughout the central and northern parts of the country between 1961 and 1963. The Sudan reported no cases at all in 1963, 1964 and 1966; in 1965, 69 cases occurred as a result of importations. However, in the country's 3 southern provinces, which had a population of about 2.5 million, government health services were restricted to the larger towns because of a protracted, devastating civil war. Thus, the status of smallpox in the extensive rural areas of the south could not be known with certainty. Even so, there was hope that the disease might not be present. No cases were being detected in the towns, no imported cases from this area were being found in adjacent countries despite the considerable numbers of migrants and travellers, and reports reaching WHO from revolutionary groups in the south indicated

that no known cases of smallpox were occurring. Moreover, the area was sparsely populated, making the sustained transmission of smallpox difficult.

Agreements to undertake eradication programmes were signed by the Zairian government in November 1966 and by the Sudanese government in April 1967. In both countries, the plans called for the administration of BCG (antituberculosis) vaccine to children and adolescents at the same time as the whole population was being vaccinated against smallpox. It was the first time a national programme had been attempted which incorporated the simultaneous administration of the two vaccines. The concept seemed sensible but, logistically, there were problems because the BCG vaccine had to be administered intradermally. In Zaire, inoculation was performed at collecting points, and there it eventually proved feasible to use the jet injectors for both smallpox and BCG vaccination. In the Sudan, however, the jet injectors were not practical because in many areas the population was not accustomed to assembling at collecting points. Smallpox vaccine was therefore administered with the bifurcated needle by vaccinators moving from house to house, but the administration of BCG vaccine by syringe and needle was too cumbersome to permit this procedure. Accordingly, programme staff endeavoured, without great success, to gather the children at assembly points.

In addition to the problems inherent in administering two vaccines rather than one, both programmes faced other difficulties, including those of conducting campaigns in large areas in which civil disorder was prevalent. Moreover, in Zaire, trained manpower in all sectors of government was scarce, communication facilities were few, the network of roads was limited and in poor repair, and travel through dense tropical rain forests was difficult. However, a highly effective vaccination campaign began to take shape there in 1968, and by July 1971 a carefully assessed systematic programme had been completed throughout the country during which smallpox vaccine was given to more than 24 million persons and BCG vaccine to more than 11 million. The last recorded case of smallpox appears to have occurred in June 1971.

Because of the lack of trained staff and the size of the country, organized surveillance was not developed until after the completion

of the vaccination campaign, and thus few outbreaks were investigated. However, an excellent surveillance system subsequently evolved, which served to strengthen the existing health structure and to confirm the absence of smallpox. Between 1970 and 1986, more than 400 cases of monkeypox, a disease clinically resembling smallpox (see Chapter 29), were eventually discovered.

The hope that the Sudan would remain free of smallpox was shattered late in 1968, when increasing numbers of cases began to be detected among persons living in the war-stricken south near the Ethiopian border and among migrant agricultural labourers from that area. Meanwhile, a mass vaccination campaign had been initiated in provinces in the central part of the country, but it was disrupted by the occurrence of cholera in 1970–1971. Although the investigation and containment of all suspected cases in a country believed to be smallpox-free were considered by WHO to be of high priority, no programme for the purpose was developed. Smallpox spread across the country in 1970 and 1971. In only 2 African countries that were free of smallpox in 1967 did endemic smallpox become re-established, and the Sudan was the first of these. Finally, in January 1972, a Sudanese medical officer took the initiative of developing a surveillance–containment programme which interrupted transmission with such unexpected rapidity that WHO consultants recruited to help to strengthen the operation arrived just as the last cases were occurring. Thereafter, Sudanese surveillance teams assisted Ethiopian staff in search activities along the border, as well as in Ethiopia itself.

ZAIRE

Background

Zaire, Africa's third largest country, is mostly low plateau (average altitude, 500 metres), comprising the central basin of the Zaire (formerly Congo) river and its tributaries. Higher plateaux surround the low plateau, rising to mountains in the east. Extending 2300 kilometres from east to west, much of the country is covered by dense tropical rain forest, giving way at higher elevations to wooded savanna and grassland. Throughout central Zaire, temperatures are uniformly high (24–27 °C), as is the humidity.

In 1967, almost 90% of the inhabitants were rural dwellers, many living in clusters of 10–20 houses along roads or tracks. Of the 233 000 kilometres of roads, only 3000 kilometres were of the all-weather asphalt type. In extensive riverine tropical rain forest areas, villages could be reached only by boat or on foot. Kinshasa, the capital (then called Léopoldville), was the largest city in tropical Africa (population, about 1 million), but there were 9 other cities in Zaire with populations of 100 000 or more. Telegraphic and postal services were limited and unreliable; communication among the various tribal groups, speaking more than 200 different languages and dialects, posed a problem.

Zaire became independent in June 1960 but within a week, an army mutiny and threatened secession brought in a United Nations peace-keeping force, which remained for 4 years. A large-scale United Nations technical assistance programme was also initiated and continued in operation until 1969. With the departure of the United Nations forces, rebellion recurred throughout the north-eastern provinces and sections of those in west-central Zaire. After the autumn of 1965, the conflict gradually subsided, but security in parts of the country remained a problem for several years. During the long period of fighting, roads and bridges were destroyed or deteriorated, and the structure of the health services was greatly weakened. Not surprisingly, few persons were vaccinated against smallpox during this time.

Trained personnel throughout the country were proportionately far fewer in Zaire than in most African countries. Primary education had been made widely available during the 1950s, but few people had been educated in secondary schools or institutions of higher learning. There were, for example, no national physicians in 1960, only 88 in 1965 and only 221 in 1970.

Because of the dearth of educated national staff, United Nations and bilateral technical assistance programmes provided many of the necessary senior and middle management personnel for the government. In the health sector, there were, in 1965, 427 foreign physicians, of whom 86 were provided by WHO and 75 by Belgian and French assistance; the remainder worked primarily in mission hospitals and clinics or were under contract with the government.

To carry out a national programme with the situation as it was in 1967 represented a formidable undertaking.

Smallpox Before 1967

During the decades preceding the beginning of the programme, several thousand cases of smallpox had been recorded annually in Zaire, but, because reporting was poor, this represented only a minute fraction of the total which had occurred. The disease was prevalent throughout the year, with no seasonal fluctuations. Mass vaccination campaigns had been conducted sporadically in urban areas and in some rural districts, but vaccination, employing locally produced liquid vaccine, was frequently unsuccessful.

It is probable that both variola major and variola minor prevailed in the country at different times. However, from 1962, smallpox with a case-fatality rate of 5–15%, similar to that in western Africa, was most widely prevalent. Official reports from Zaire usually distinguished between variola major and variola minor (Table 18.1). From these data, the inference might be drawn that variola major, similar in severity to that which occurred in Asia, coexisted with variola minor. During the course of the programme, however, it became apparent that health staff usually based their reports simply on the severity of the disease. Milder cases were customarily reported as variola minor and more severe cases as variola major.

Before 1962, overall case-fatality rates were below 5%, but subsequently they ranged from 5% to 15%. Since no changes are known to have occurred in reporting prac-

tices, it is presumed that a more serious form of the disease became more widespread about this time. After 1962 there were occasional undocumented anecdotal reports of outbreaks with few or no deaths; conversely, in Kinshasa a 1961–1962 epidemic was reported in which 280 (27%) of 1021 cases died. However, in the Kinshasa outbreak almost all the cases reported (of which 70% were in children under 5 years of age) were of the more severe type, requiring hospitalization.

Whatever the cause of the higher case-fatality rate, the government authorities of the newly independent country, as well as the foreign medical officers working there, were concerned about smallpox. In 1962–1963, they held meetings with the WHO medical officer for smallpox from Geneva to plan a pilot programme in one of the provinces. It was hoped that this would be followed by a national smallpox vaccination campaign. WHO was asked to provide medical officers, vehicles and equipment, but because of civil war, it was not possible to follow up the request. Meanwhile, smallpox vaccination throughout the country all but ceased. In 1965, WHO was again approached with a fully elaborated plan for a 4-year country-wide vaccination campaign, during which smallpox and BCG vaccines would be administered simultaneously. Such a programme had not been attempted before, in part because of the problems inherent in administering BCG vaccine.

Up to 1964, the administration of BCG

Table 18.1. Zaire: number of reported cases of and deaths from smallpox, and case-fatality rates, 1956–1971

Year	Variola major ^a			Variola minor ^a			Total ^a		
	Number of cases	Number of deaths	Case-fatality rate (%)	Number of cases	Number of deaths	Case-fatality rate (%)	Number of cases	Number of deaths	Case-fatality rate (%)
1956	970	157	16.2	3 693	63	1.7	4 663	220	4.7
1957	256	44	17.2	1 694	22	1.3	1 950	66	3.4
1958	57	5	8.8	1 124	11	0.9	1 181	16	1.4
1959	369	44	11.9	2 666	30	1.1	3 035	74	2.4
1960	...	...	...	...	...	...	1 408	...	...
1961	...	...	...	...	...	...	3 624	149	4.1
1962	2 430	498	20.5	1 345	43	3.2	3 775	541	14.3
1963	4 097	668	16.3	1 426	42	2.9	5 523	710	12.8
1964	1 964	136	6.9	1 298	26	2.0	3 262	162	5.0
1965	1 990	255	12.8	1 793	81	4.5	3 783	336	8.9
1966	...	...	...	...	...	...	1 913	171	8.9
1967	...	...	...	...	...	...	1 479	112	7.6
1968	2 995	304	10.1	805	9	1.1	3 800	313	8.2
1969	1 944	207	10.6	128	0	0.0	2 072	207	10.0
1970	— ^b	— ^b	— ^b	— ^b	— ^b	— ^b	716	69	9.6
1971	— ^b	— ^b	— ^b	— ^b	— ^b	— ^b	63 ^c	3	4.8

^a ... = data not recorded.

^b For reporting purposes, no distinction was made between variola major and variola minor.

^c Includes 2 cases of chickenpox incorrectly notified as smallpox.

vaccine required that each potential vaccinee should be visited twice, with an interval of 2 days between visits. At the first visit, a non-infectious purified protein derivative (PPD) of the mycobacterium was injected intradermally, and 2 days later the site of injection was examined. The presence of a specified amount of induration at the test site indicated that the child had been infected with tuberculosis. Such children would not benefit from vaccination and thus were excluded from the group given BCG vaccine. The possibility of vaccinating all children, irrespective of whether or not they had had tuberculosis, had been considered, in order to eliminate the cumbersome and time-consuming process of prior testing with PPD. However, the occasional occurrence of unusually severe reactions to vaccine in the already infected group had contraindicated this approach. The WHO Expert Committee on Tuberculosis (1964) discussed the question at length and concluded that, as a practical matter, there was little choice in many countries but to eliminate testing with PPD on the premise that the overall benefits conferred by a logistically simplified BCG vaccination campaign outweighed the risk of a few serious reactions. This change in procedure made it more feasible to administer both vaccines at the same time. Moreover, because UNICEF was supporting many national BCG vaccination campaigns, but not those for smallpox, it was hoped that a combined campaign would elicit from UNICEF material assistance in the form of transport and equipment. The plan called for a national staff of 650, supported by 9 medical advisers, an operations officer, a statistician and an administrator made available by WHO. The magnitude of the programme and the proposed substantial commitment of government resources reflected a degree of interest in smallpox eradication in Zaire that was exceptional in African countries.

The Eradication Programme Begins, 1967-1968

Because of the considerable United Nations and WHO commitment to Zaire, an office in WHO Headquarters rather than in the WHO Regional Office for Africa coordinated the Organization's activities in Zaire until 1968, dealing with such matters as the recruitment of staff and the procurement of supplies. In

November 1966, a medical officer from the Smallpox Eradication unit at Headquarters held discussions with national and WHO staff in Zaire and finalized a similar although somewhat more modest plan than that originally proposed by Zaire. Most of the support was to be provided by WHO, UNICEF agreeing to supply only the BCG vaccine, as well as the needles and syringes for its administration.

The overall operational strategy for vaccination was not dissimilar to that in other African countries. It called for 4 large vaccination groups, each composed of 6-8 teams. Each group would be directed by a WHO medical officer and, where available, a Zairian counterpart. Every team would have a supervisor; 3 pairs of vaccinators (a "vaccination unit"), one of each pair giving smallpox vaccine and one BCG vaccine; and a "control unit" of 3 vaccinators and a sanitary agent to visit a sample of the villages one week after vaccination to verify coverage and vaccination results. It was expected that each pair of vaccinators would be able to give 140 smallpox vaccinations and about 70 BCG vaccinations a day. Smallpox vaccination would be performed by scarification and BCG vaccination by intradermal inoculation using a syringe and needle. Village chiefs and local authorities would be notified in advance and asked to bring the people together at a convenient collecting point. In view of tribal and linguistic differences from area to area, local recruitment and the secondment of personnel from existing health services were anticipated.

The WHO senior medical officer was to be designated "co-director" of the programme rather than "adviser", in recognition of the more substantial role that the Organization was intended to play. In addition to the 4 medical officers who were to head the vaccination groups, WHO was also to provide an administrator, a public health nurse and a statistician—in all, 8 staff members, plus short-term consultants. The government complement was expected to amount to 363 persons, of whom 260 would be vaccinators. The cost to the government was set at US\$353 800 for the 1967 pilot project and at US\$677 000 annually for the principal "attack phase", which was scheduled to extend from 1968 to the end of 1970.

At the outset, WHO provided 34 Land Rovers with trailers, 6 trucks, 5 outboard motors, 14 motor cycles, 10 refrigerators plus

Table 18.2. WHO support for the Zaire programme, 1967-1975 (US\$)^a

Year	Supplies and equipment	Personnel and other costs	Total
1967	160 869	69 428	230 297
1968	48 616	82 238	130 854
1969	259 254	87 674	346 928
1970	99 761	149 097	248 858
1971	28 884	251 046	279 930
1972	120 198	238 488	358 686
1973	78 512	130 402	208 914
1974	78 051	130 043	208 094
1975	37 942	105 065	143 007
Total	912 087	1 243 481	2 155 468

^a Excluding the cost of 36 878 000 doses of vaccine.

camping gear, office equipment, megaphones and other miscellaneous supplies. WHO's support for this programme up to 1974 represented, on average, about 8.5% of all funds earmarked for smallpox eradication in the Organization's regular budget (Table 18.2).

Following completion of the mass vaccination campaign, it was expected that maintenance vaccination would be continued by the established health units, which by 1972 included 302 hospitals, 45 clinics, 2705 dispensaries and 242 maternity wards. Little attention was paid to reporting and surveillance in the 1966 plan of operations, reflecting the minimal interest in this component of the programme before 1967. As was stated in the plan: "Long-term objectives are to main-

tain smallpox eradication by appropriate surveillance methods as will emerge from experience and evaluation."

The post of WHO co-director was assigned to Dr Vladimir Zikmund, a WHO epidemiologist already working in Zaire; Dr Lekie Botee, a young Zairian medical officer, was appointed the national co-director—he was to serve in this role with great distinction throughout the early phases of the programme and later, to provide invaluable support as Director-General of Health Services.

The plan called for a pilot programme, to be initiated in 1967, in the course of which 2 groups would administer 2.86 million vaccinations; a full-scale programme, employing 4 operational groups, was scheduled to begin in 1968. Completion of the vaccination phase was foreseen by the end of 1970.

Because of difficulties in organizing so extensive a programme in a country only beginning to recover from civil war, progress was slow at first. Equipment began to arrive in July 1967 and most had been received by October. Two WHO medical officers, already assigned for work in Zaire, were transferred to the programme and a part-time finance officer was made available. At this point, efforts to recruit the remaining promised complement of WHO staff all but ceased. WHO's technical assistance programme in Zaire diminished significantly in scope as from 1967-1968, and responsibility for the Organiza-



Plate 18.1. **A:** Lekie Botee (b. 1930), the first Zairian co-director of the smallpox eradication programme in Zaire; when, later, he became Director-General of Health Services of Zaire he continued to play an active role in the programme. **B:** Pierre Ziegler (b. 1925), WHO co-director from 1968, was instrumental in redirecting operations and in establishing a management system.

tion's activities in Zaire was transferred to the Regional Office for Africa, which had only a small staff, a host of countries to serve and a staggering array of problems. Repeated pleas for additional staff were made but more than a year was to elapse before an administrative officer arrived; not until July 1971 was the promised complement of WHO staff made available.

Preparations for the field programmes were handicapped by the need for the medical officers to spend much of their time on administrative matters, including the creation of a central administrative office, the clearance of supplies through an inefficient customs office and their inventory and storage, and the shipment of vehicles and equipment to provincial capitals which were to serve as bases for field operations. Obtaining the release of government funds was yet another problem which persisted throughout the course of the programme, not infrequently requiring special intervention by the Minister of Health when depleted allocations threatened to stop activities. The part-time WHO finance officer, Mr S. O. Axell, wise in his knowledge of government, eventually obtained agreement to have the allotted funds deposited in a special bank account, and, in time, several such accounts were opened. When delays occurred in obtaining the funds allocated, especially at the beginning of a fiscal year, and the principal account was empty, reserves in the auxiliary accounts were used until the crisis could be resolved.

Because of the difficulties in getting the programme started, the pilot project in 1967 was limited to Kinshasa. It was not an auspicious beginning. The WHO co-director, seeking to ensure a thorough vaccination coverage, proposed that a census should be taken at the same time as the vaccinations were performed so that it could be known precisely what proportion of the population had been vaccinated. Thus, the vaccinators were instructed to prepare a separate card for each family, listing all members by name, age and sex and noting the date of vaccination. Later, an assessor visited each house, issued a special vaccination certificate to each individual successfully vaccinated and revaccinated those whose vaccination had not taken or who had been missed. The process was cumbersome and time-consuming. On average, the vaccinators performed only 20–30 vaccinations a day, and the Kinshasa programme concluded with only 220 000

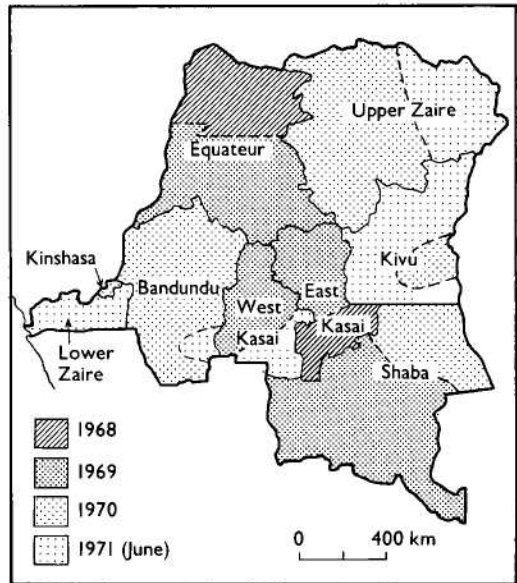


Fig. 18.2. Zaire: areas whose population was vaccinated in the systematic campaign, 1968–1971.

persons having been vaccinated in a target population of 1 million. Although the methodology was obviously faulty, no changes were made as the programme shifted from the pilot project stage to a mass vaccination campaign.

Three vaccination groups had been expected to begin work in 1968, but with only 2 WHO medical officers available to direct them, the programme was launched in only 2 provinces—East Kasai and Equateur (Fig. 18.2). In February, more vaccinators were recruited and trained and, in March, approximately 70 staff began work in East Kasai and 60 in Equateur. On 29 March 1968, a presidential decree gave the programme official status. For smallpox vaccination, most of the staff used the newly available bifurcated needles. In East Kasai, a number of jet injectors, such as were then in use in Brazil and western Africa, were supplied for large-scale vaccination at collecting points.

The jet injectors immediately proved to be widely favoured by the population and permitted the teams to vaccinate many more persons each day. However, the operational problems which characterized the pilot project worsened. The efficiency of the jet injectors was compromised by 3 facets of the programme: (1) the complex enumeration process; (2) the need to distribute vaccination certificates; and (3) the coordination of

smallpox vaccination with the time-consuming intradermal inoculation of BCG using a syringe and needle. Other methods were tried for enumerating the population. Special teams visited each area before vaccination and collected information by house-to-house visits or at collecting points. To simplify the process further, it was decided to record only the names of the heads of households, along with the number of household residents. In addition, efforts were made to persuade village leaders to provide this information. However, it was discovered that the number of people recorded as having been vaccinated in each village was greater than the total enumerated, the discrepancy being accounted for by an inadequate enumeration process and the fact that many individuals from outside the area attended the vaccination sessions. It became apparent that enumeration was a futile exercise. The name of the individual concerned had to be written on each vaccination certificate, after which it was stamped with an official stamp. For each jet injector in operation, on average 6 clerks were required to prepare the certificates. Lastly, the administration of BCG vaccine was an awkward procedure, often requiring, as one observer noted, 2 persons to hold the child and a third to inoculate.

The staffing patterns of the teams were changed to assign more persons to clerical work and to BCG vaccination, but progress remained discouragingly slow. By the end of September, smallpox vaccine had been given to 1 477 000 people and BCG vaccine to 644 000; at this rate the country-wide programme would have taken 8 years to complete.

The Restructuring of the Programme, September 1968

In September 1968, a new WHO co-director—Dr Pierre Ziegler—was appointed. Dr Ziegler had previously served for 16 years in Chad directing a mobile disease prevention and treatment service. During 1967, he worked there with United States Communicable Disease Center staff in the smallpox eradication-measles control programme and understood clearly the practicalities of executing a field programme. Dr Ziegler and Dr Lekie Botee decided to cease the enumeration activities. Instead, a sample survey of 5% of the villages was conducted after 6–8 days to

assess the take rates of smallpox vaccination, and again after 2–3 months to assess the take rates of BCG vaccine and overall vaccination coverage. The problem of vaccination certificates proved to be more difficult to deal with because the government insisted on their use and the population was accustomed to receiving them. Procedures for their issuance, however, were greatly facilitated by requiring a member of the team to stamp the certificates and by asking the vaccinee to enter his or her name on the document. Finally, the teams began to use the jet injectors to administer BCG vaccine as well, a recently (albeit incompletely) evaluated technique of BCG vaccination. WHO regional personnel and national tuberculosis advisory staff, in deference to tradition, objected to the adoption of this practice, but eventually acquiesced when Dr Halfdan Mahler, then Chief of the WHO Tuberculosis unit, endorsed it and ordered all to cooperate.

Each vaccination group was reorganized to consist of 5 teams, each with a Land Rover and 5 jet injectors. Every team had 6 members—the team leader, 1 vaccinator for smallpox vaccine and 1 for BCG vaccine, a person to stamp and distribute certificates, another to tally the vaccinees and reconstitute the vaccine, and a driver. One additional team worked with each group to contact the chiefs of all villages 1 or 2 days before the vaccination teams arrived, to explain the programme and to obtain the cooperation of village leaders. An assessment team made up the rest of the field staff.

Each operational group maintained a headquarters in the capital city of the province in which it was working and temporary field camps as it moved through the province. In addition to the field teams, each group had a small administrative unit—a total complement of about 50 persons. Each group was equipped with 10 Land Rovers, 2 trucks, 30 jet injectors and several refrigerators. Each team had specific daily and monthly targets, but was allowed a certain flexibility in its schedule to accommodate the need for frequent long trips by boat and on foot.

The pace of activity began to increase. During the last 3 months of 1968, as many people were vaccinated as during the first 6 months of the programme. By the end of the year, 2 275 000 smallpox vaccinations had been performed over a broad area stretching across the central part of the country. Here, assessment revealed that, except in the most

A Problem Bred by Efficiency

The vaccine standards called for the freeze-dried smallpox vaccine to retain its potency for 30 days when incubated at 37 °C. Thus, in all programmes, provision was made to refrigerate the vaccine at 4 °C at central storage depots and at distribution points in the field to ensure, as far as possible, that vaccine reaching the vaccinee was fully potent. The diluent for the vaccine, however, did not need to be refrigerated. Much of the vaccine provided to WHO came from the USSR, which, like most vaccine manufacturers, packaged both vaccine and diluent in the same box. With this manner of packaging, much more refrigerated storage space was required than if the diluent and vaccine had been packaged separately. Because refrigerated storage facilities were at a premium in all countries, WHO approached the Soviet authorities and proposed that the two should be separately packaged and this was agreed. In 1970, vaccine and diluent began to be distributed in separate boxes, which were clearly marked and had labels of different colours so that there would be no confusion.

Regrettably, the change in the manner of packaging was not at first noted in Zaire until a vaccination team, after 3 weeks' journey into the forest, opened the boxes to begin a vaccination campaign—only to find that they had brought with them nothing but diluent.

isolated districts, more than 90% of the population were being vaccinated. On average, each team was able to administer daily 1200 smallpox vaccinations and 600 BCG vaccinations. In only a few months, Dr Ziegler and Dr Lekie Botee, assisted by 2 WHO group leaders, Dr P. Cartagena and Dr E. Zanotto, had transformed a chaotic operation into a remarkably efficient machine.

In January 1969, the programme began to publish a monthly surveillance bulletin, which was distributed to 943 health units throughout the country. It documented the numbers of cases reported from each province and the progress of the campaign, exhorted all to report cases of smallpox, and urged health units to undertake vaccination.

Until 1969, few of the personnel in the extensive network of health centres, clinics and hospitals had administered vaccines of any type. Those who had done so had been supplied with either liquid smallpox vaccine or a substandard freeze-dried product produced by a laboratory in Lubumbashi. A WHO consultant was recruited to determine whether, with assistance, the laboratory could produce satisfactory vaccine, but the problems were too numerous and the laboratory was closed. In June 1969, it was agreed that only vaccine that met WHO requirements would be used, and thereafter vaccine supplied by WHO, emanating principally from the USSR, replaced the local product. With the continuing encouragement of the small-

pox eradication programme staff, the numbers of smallpox vaccinations performed in health centres and clinics increased from 575 000 in 1968 to 3 575 000 in 1969, although some health centre staff, preoccupied with curative medicine, refused to participate in the campaign.

In February 1969, Mr A. Samy, an administrator, was recruited by WHO. A resourceful and experienced person, he soon established a sophisticated vehicle repair and maintenance workshop—a necessity because, as noted in a report: "Despite more than 3000 Land Rovers in service in the country, the after-sales service provided is inadequate as for repair and often nonexistent concerning locally available spare parts." Records of repair and maintenance schedules were established for all vehicles, mechanics were recruited and trained, and trailers were rebuilt to permit them to carry petrol, often unavailable in remote parts of Zaire. A workshop for repair of the jet injectors was also established, along with an inventory of spare parts.

The logistic and operational problems were formidable but programme staff, with ingenuity and persistence, competently dealt with them. The recruitment of the required WHO staff, the placement of orders for equipment and the arrangements for its shipment were, however, beyond their control, these tasks being the responsibility of the WHO regional office. All were greatly delayed. Even the use of BCG vaccine had to be



Plate 18.2. **A:** The protracted fighting in Zaire devastated the road system, and vehicles frequently became mired along bush trails. **B:** Broken chassis were common; without a special repair and maintenance workshop, the programme would have foundered.

interrupted for a period when UNICEF decided to send the vaccine by air but the diluent for reconstituting it by sea. The only supplies which did not present a problem were smallpox vaccine, bifurcated needles and jet injectors. These could be provided promptly, on request, from a reserve stockpile held at WHO Headquarters.

In January 1969, Dr Ziegler and Dr Lekie Botee decided—and the government supported them with an appropriate request to the regional office—that persons with qualifications similar to those of staff employed by the United States Communicable Disease Center in western Africa should be recruited as WHO operations officers. It was expected that they would organize provincial surveillance teams so as to strengthen reporting and investigate outbreaks. WHO agreed to recruit 5 such persons, but more than 2 years were to elapse before 4 of the 5 arrived. Meanwhile, with only 2 WHO medical officers available for field work and no Zairian staff who could independently supervise field activities, Dr Ziegler and Dr Lekie Botee had no option but to pursue the vaccination campaign, postponing surveillance until adequate staff became available.

The vaccination campaign steadily gained momentum: between April and June 1969 an average of about 500 000 smallpox vaccinations were administered each month, com-

pared with only 200 000 a month the year before. In July, a third vaccination group was able to begin work under the supervision of a WHO medical officer recruited from among the foreign medical staff remaining in Zaire. He was replaced later that year by the first of the WHO operations officers, Mr Garry Presthus, who was to provide able assistance first in Zaire and later in Botswana. By the end of 1969, more than 8 million persons had received smallpox vaccine and almost 3.5 million BCG vaccine (Fig. 18.3). The total was less than the optimistic target projected in 1966, but the gap was narrowing. The results of continuing assessment showed a vacci-

Table 18.3. Zaire: number of reported cases of smallpox, by province and year, 1967–1971

Province	Number of cases				
	1967	1968	1969	1970	1971
Bandundu	145	983	401	126	0
East Kasai	327	618	23	17	1
Equateur	61	10	70	8	0
Kinshasa	0	124	31	4	0
Kivu	235	339	293	401	35
Lower Zaire	26	33	50	13	15
Shaba	391	1391	898	64	7
Upper Zaire	25	44	236	83	3
West Kasai	269	258	70	0	2 ^a
Total	1 479	3 800	2 072	716	63 ^a

^a Two cases of chickenpox incorrectly notified as smallpox.

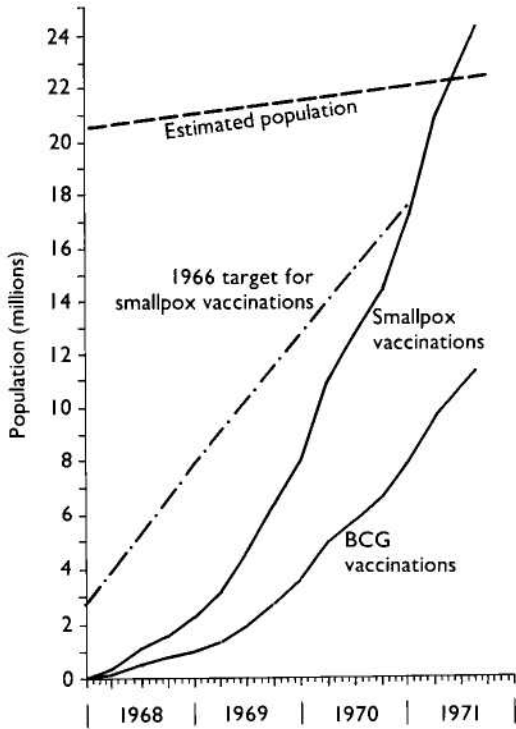


Fig. 18.3. Zaire: estimated population and numbers of smallpox and BCG vaccinations performed from 1968 to June 1971, compared with the 1966 target for smallpox vaccinations.

nation coverage which frequently exceeded 95% and was never below 80%.

The number of recorded cases decreased from 3800 in 1968 to 2072 in 1969 (Table 18.3; Fig. 18.4), a significant reduction in view of the fact that more medical units, encouraged through the monthly surveillance bulletin, began to report each week the number of cases of smallpox seen. During 1969, an average of 87 medical units out of an estimated 535 provided weekly reports—a far from optimum response but an improvement over 1968. The highest proportion of reports was received from the provinces in which the vaccination groups had worked and the medical units had been most thoroughly briefed about the programme. In East Kasai Province, in which the vaccination campaign was completed in February 1969, the results were dramatic (Fig. 18.5).

The Vaccination Campaign Becomes Fully Established, 1970

Most of the supplies and equipment had been received by 1969 (Table 18.4), sufficient to meet the needs of 4 vaccination groups, but it was not possible to establish a fourth group

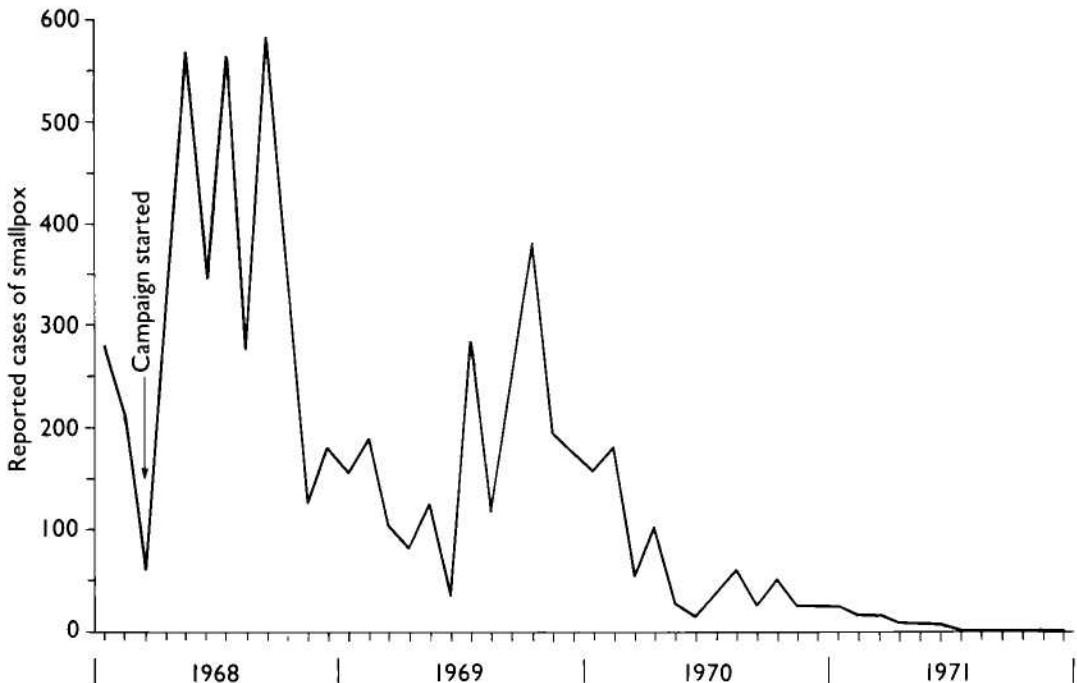


Fig. 18.4. Zaire: number of reported cases of smallpox, by month, 1968–1971.

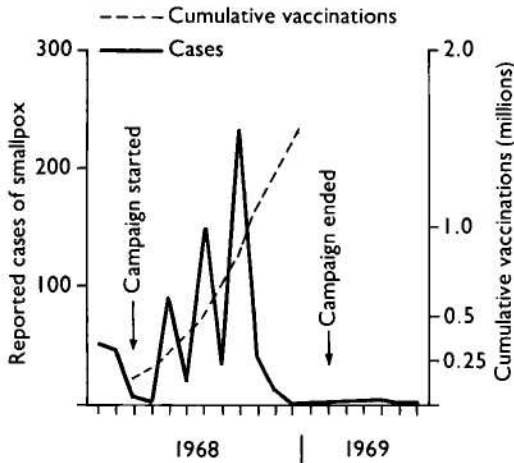


Fig. 18.5. East Kasai Province: number of reported cases of smallpox and number of vaccinations performed, by month, 1968–1969.

until February 1970, when Dr Ziegler succeeded in arranging for the transfer of another locally employed foreign medical officer, Dr A. Hornbanger. In just 8 weeks Dr Hornbanger's group of 7 teams, based in Kinshasa, performed more than 1.6 million smallpox vaccinations and 800 000 BCG vaccinations in the city; during March, each team of 6 persons gave, on average, 5300 smallpox vaccinations and 2800 BCG vaccinations a day.

With 4 groups in the field, the complement of national personnel increased until it reached its highest number—234 persons—a ratio of 1 staff member for about 100 000 inhabitants (Table 18.5). There were 9 international staff. The vaccination campaign progressed rapidly despite the fact that groups were beginning to spend more time in the least accessible regions of the country, where travel by boat and on foot was frequently required. For example, one group, consisting of 50 persons, which had succeeded in vaccinating 915 000 people in one month in an accessible, more populated, area, was able to

Table 18.4. Zaire: inventory of major equipment, by year, 1968–1972

	1968	1969	1970	1971	1972
Vehicles	48	52	65	65	73
Motor cycles	92	92	92	0	0
Motorboats	5	6	10	10	12
Freezers	0	3	17	17	13
Refrigerators	12	15	15	12	9
Jet injectors	37	143	143	143	143

Table 18.5. Zaire: smallpox eradication programme staff, by category and year, 1968–1972

Category	Numbers at end of year				
	1968	1969	1970	1971	1972
National staff:					
Medical officers	1	1	1	1	1
Office clerks/typists	13	12	14	10	11
Supervisors	0	2	4	0	0
Team leaders	13	13	25	9	11
Vaccinators	51	55	92	10	11
Drivers/mechanics	25	34	60	18	21
Others	23	24	38	26	28
Total	126	141	234	74	83
WHO staff:					
Medical officers	3	4	5	5	3
Administrative officers	1	2	2	2	1
Operations officers	0	1	2	5	3
Total	4	7	9	12	7
United States Peace Corps volunteers	0	0	0	8	8
Total	130	148	243	94	98

vaccinate only 54 000 people during the succeeding month.

By the end of 1970, 17 million persons had been vaccinated against smallpox and systematic programmes had been completed throughout the country except in areas in which security had been a problem, and in Lower Zaire, near Kinshasa, in which few cases were being detected and which, accordingly, had lower priority.

The Problem of Surveillance

Dr Ziegler and Dr Lekie Botee continued to worry about reporting and surveillance. The recruitment of operations officers who could lead surveillance-containment teams had been expected but the arrival of only one such officer, late in 1969, was of little help. The creation of a national team was considered but, in a country so large and with travel so difficult, it was decided that this would be unproductive. Moreover, communications were a major problem, so that even when cases were discovered notification was so greatly delayed that it was difficult for a single team to be effective. For example, a telegraphic message sent in April, reporting cases in a province adjacent to Kinshasa, took a month to reach Kinshasa.

Each of the health units throughout the country continued to be encouraged to vaccinate, to report cases and to contain outbreaks. Although the average number of reports received each week increased from 87 in 1969

Table 18.6. Zaire: number of reported cases of smallpox, by province and month, 1970 and 1971

Province	1970											1971										
	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.
Bandundu	53	54	1	0	4	0	2	6	0	0	6	0	0	0	0	0	0	0	0	0	0	0
East Kasal	0	1	1	2	0	5	0	0	2	6	0	0	0	0	1	0	0	0	0	0	0	0
Equateur	0	1	2	0	0	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Kinshasa	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kivu	93	78	21	61	1	10	19	51	5	32	13	17	9	10	3	4	0	0	0	0	0	0
Lower Zaire	0	3	0	0	0	0	0	0	0	1	5	4	15	0	0	0	0	0	0	0	0	0
Shaba	5	18	12	5	0	1	3	3	8	6	0	3	1	2	0	3	1	0	0	0	0	0
Upper Zaire	1	12	12	27	20	1	1	4	2	1	2	0	0	1	1	0	0	1	0	0	0	0
West Kasal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2 ^a	0	0
Total	153	167	50	97	25	17	28	64	17	48	26	24	25	12	12	6	5	1	0	2 ^a	0	0

^a Two cases of chickenpox incorrectly notified as smallpox.

to 140 in 1970, there were still many units which did not report at all.

During 1970, only 716 cases were reported, the lowest total recorded in Zaire since a national reporting system had been introduced. By September, fewer than 50 cases a month were being discovered, most of them in eastern Kivu Province (Table 18.6), in which the vaccination campaign was still in progress. At least some of the reported cases were thought to be chickenpox, since they were noted as having occurred in young children with a distinctive vaccination scar. In the hope of getting a more accurate assessment of this problem, Dr Ziegler and Dr Lekie Botee decided to distribute collection kits and to ask those who reported cases to submit specimens for examination by WHO reference laboratories. However, the distribution of the kits, as well as their return, proved troublesome because of the poor postal service.

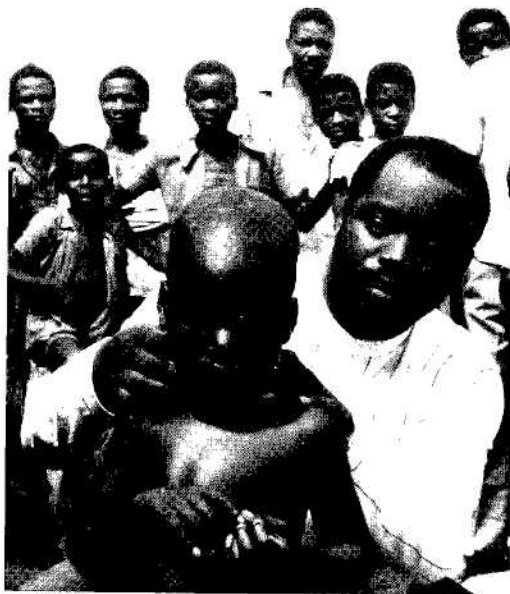
Frustrated by WHO's inaction in recruiting staff, Dr Lekie Botee and Dr Ziegler in Kinshasa and Henderson, on a special trip to Washington, approached the United States government, requesting the assignment of 8 Peace Corps volunteers from the USA. This had to be done unofficially, because at that time it was the policy of WHO that the assignment of national volunteers should be decided on and worked out by agreement between the national governments concerned. WHO staff were to play no role in encouraging their assignment in any country or in supporting their activities. However, the Zaire programme was desperate for personnel to undertake surveillance activities and there appeared to be no other alternative. United States officials were themselves not initially enthusiastic about the proposal because of their policy of assigning Peace Corps volun-

teers to specific areas in which they would become acquainted with the local people during their tour of duty. The surveillance teams, in contrast, were expected to travel constantly over an extensive area. Moreover, the task of supervising a surveillance team was felt to be unusually demanding. Reluctantly, the USA agreed to select Peace Corps volunteers who had performed especially well during a 2-year assignment and wished to extend their tour of duty for a year or more. Those appointed were to prove invaluable.

The Discovery of a Case of Monkeypox in a Human Being

The imperative need for surveillance was heightened by the identification in October 1970 of the first recognized case of monkeypox in a human being. The WHO reference laboratory in Moscow isolated monkeypox virus from a specimen collected from a child who had become ill on 22 August 1970. The virus had been isolated previously from outbreaks of disease in captive monkeys but never before from a human (see Chapter 29). Nothing was known about the possible clinical manifestations in humans or about the potentialities for spread from human to human. Recalling that yellow fever eradication had been thwarted in the 1930s when a natural reservoir in mammals had been discovered, WHO staff were deeply concerned that monkeypox virus might be analogous to sylvan yellow fever virus, perhaps dooming the objective of global eradication. Concern grew when, within a week, 4 cases in Liberia were confirmed as monkeypox by the WHO reference laboratory in Atlanta, USA.

Ladnyi, at that time the WHO inter-country smallpox adviser in eastern and



M.V. SZCZENIOWSKI, 1984

Plate 18.3. Kalisa Ruti (b. 1948) examining a patient with monkeypox. He succeeded Lekie Botee as co-director of the smallpox eradication programme in Zaire and subsequently supervised the extensive investigation of monkeypox.

southern Africa, joined Dr Ziegler early in January 1971 to investigate the case in Zaire. The child, a 9-month-old boy, had been admitted on 1 September to a hospital in Basankusu, a small town in the central part of Equateur Province. He had a rash with a distribution like that of smallpox but because the lesions were haemorrhagic, the physician was uncertain of the diagnosis and had taken a specimen. After admission the child developed enlarged cervical glands as well as otitis and mastoiditis. Subsequently, he contracted measles and died on 29 October. Ladnyi and Dr Ziegler searched for other cases with rash in Basankusu town and in the village in which the child had lived until 4 days before becoming ill. No cases could be found, although it was ascertained that the family of the patient occasionally ate monkeys, as did many other people in the area.

The nature of the area and the difficulties of travel and communication in this and many other parts of Zaire is conveyed in the report of Ladnyi and Dr Ziegler. Equateur Province was made up of 4 districts, each district consisting of a number of territories, of which Basankusu Territory was one. To travel from Kinshasa to Mbandaka, the provincial capital, and from there to Basankusu town was difficult. A weekly air flight, often cancelled,

connected Kinshasa with the two towns. Travel by road meant crossing no fewer than 20 lakes and rivers, only some of which had a regular ferry service. Twice monthly, a riverboat made a 2-day trip to Mbandaka, where, after a wait of several days, one could transfer to another boat for a further 2-day trip to Basankusu. A cable to Kinshasa often took a month or longer to deliver. Basankusu Territory covered an area of 20 000 square kilometres and had a population of 62 000, mainly primitive farmers living in small villages scattered along paths and tracks in dense tropical rain forest. The distance from the capital of the territory to the most remote villages was 150 kilometres. Only one all-weather road crossed the territory, intersected by several impassable rivers with neither bridges nor regular ferry services. Travel along the tracks and paths was difficult, the so-called rainy season being 10 months long; even in the drier months, rain fell 2 or 3 days a week.

Basankusu Territory was served by a government hospital and 18 dispensaries scattered throughout the area, some operated by government health staff and some by missionaries. Smallpox had been present in the district in 1968 but no cases were known to have occurred in 1969. Two cases had been reported in 1970, one of which was discovered to have been chickenpox; the other was the case of monkeypox.

Vaccination had been performed by the teams in 1969, but no special containment vaccination programme had been conducted after discovery of the monkeypox case. Ladnyi and Dr Ziegler carried out a vaccination scar survey in 6 villages near where the patient lived, 115 kilometres from Basankusu town. The results are indicative of the thoroughness of the vaccination campaign (Table 18.7).

Twenty-one persons had characteristic residual pockmarks of smallpox but their illnesses had all occurred before or during 1968,

Table 18.7. Basankusu Territory: results of vaccination scar survey, by age group, 1970

Age group (years)	Number assessed	Subjects with vaccination scars	
		Number	%
0-4	186	159	85.5
5-15	358	339	94.7
≥ 16	588	567	96.4
Total	1 132	1 065	94.1

when smallpox had been widely prevalent. In this instance, at least, monkeypox appeared not to have spread to other human beings. The results of this and subsequent investigations of cases of monkeypox are described in Chapter 29. Eventually the studies confirmed that cases of monkeypox in humans were rare and that the disease spread only with difficulty from human to human.

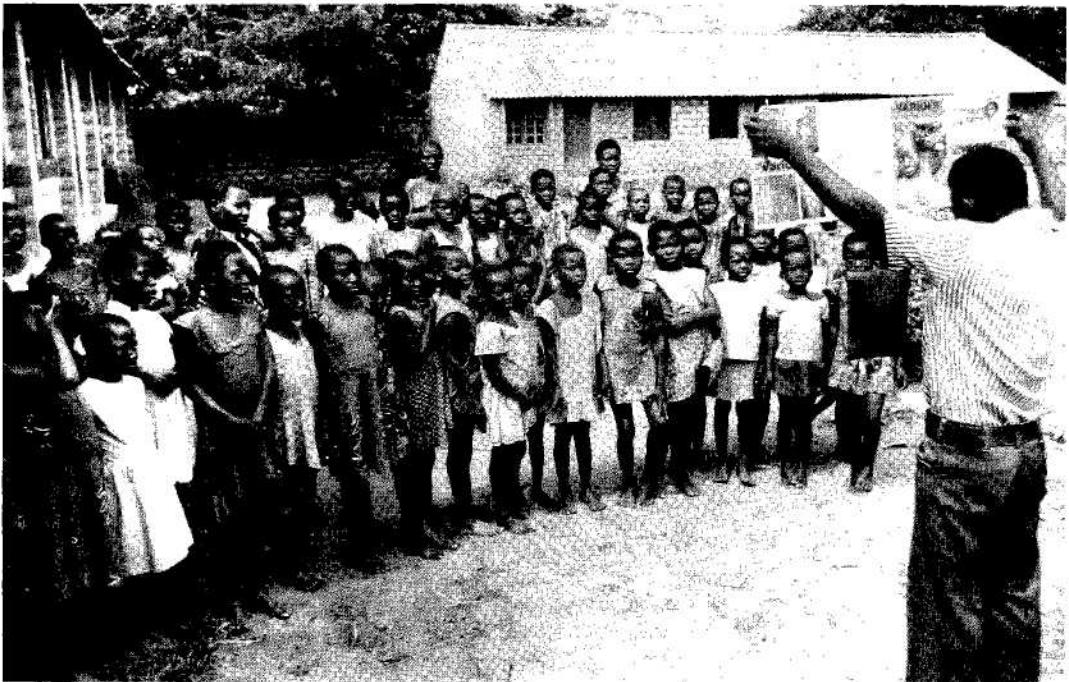
The Creation of a Surveillance Programme, 1971

In January 1971, 5 provincial surveillance teams were established with the eventual arrival of 2 additional WHO operations officers and 3 United States Peace Corps volunteers. One of the 2 operations officers, Mr Mark Szczeniowski, was to remain with the programme in Zaire over the following 15 years, continuing the programme of surveillance and supervising special investigations of monkeypox. Each of the teams had a vehicle, a driver, a Zairian counterpart and a vaccinator. Each was equipped with a 100-watt transceiver in order to communicate rapidly with Kinshasa, with their provincial base of opera-

tions, and with each other. In their respective areas, they began to visit in a systematic fashion all hospitals, dispensaries and health centres to inquire about possible cases, to request immediate notification of any suspected case, to distribute vaccine and needles and to encourage each establishment to vaccinate everyone who attended it. Each health facility was visited once or twice every 6 months. The teams investigated all suspected cases and obtained specimens. In addition, in different villages they undertook a random scar survey assessment of about 2000 persons each month to assess the status of vaccinal immunity. Each team spent 21 days in constant travel, followed by a week's holiday.

By July 1971, 11 surveillance teams were in operation; 2 were assigned to each of the 3 largest provinces, and 1 each to the smaller ones. With the termination of the vaccination campaign at the end of July, the numbers of national staff were reduced and the medical officers who had served as group leaders each assumed supervisory responsibility for several provinces.

During the vaccination campaign, more than 24.3 million persons were vaccinated against smallpox and 11.4 million received



J. G. BREMAN

Plate 18.4. The surveillance programme in Zaire began in January 1971 and continued into the 1980s as teams sought human cases of monkeypox, a disease clinically almost identical to smallpox. Schoolchildren were shown pictures of smallpox in the WHO pictorial guides and asked if they had seen any cases.

Table 18.8. Zaire: population and number of reported smallpox and BCG vaccinations, by province, March 1968–July 1971

Province	Population, 1971 estimate ^a (thousands)	Number of vaccinations performed		Period
		Smallpox	BCG	
Bandundu	2 672	2 630 261	1 364 991	June 1970–Jan. 1971
East Kasai	1 922	1 659 454	589 277	March 1968–Feb. 1969
Equateur	2 497	2 593 747	1 006 667	March 1968–Dec. 1969
Kinshasa	1 359	1 802 151	951 430	Feb. 1970–May 1970
Kivu	3 452	4 675 079	2 258 582	Sept. 1970–July 1971
Lower Zaire	1 544	1 756 221	949 430	Jan. 1971–June 1971
Shaba	2 828	3 869 180	2 003 529	April 1969–June 1970
Upper Zaire	3 446	3 524 230	1 405 349	Feb. 1970–May 1971
West Kasai	2 499	1 836 095	827 673	July 1969–May 1970
Total	22 219	24 346 418	11 356 928	

^a Derived from United Nations (1985).

BCG vaccine (Table 18.8). All parts of the country had been reached except for a small area in Kivu Province with a population of 115 000 persons. Even there, where security remained a problem, the staff were able to vaccinate some 50 000 people, although not in the systematic manner in which the rest of the campaign had been conducted.

The number of cases diminished rapidly during 1971. No cases were discovered in July and only 2 in August—the last reported cases in Zaire. The occurrence of these 2 cases, in West Kasai Province, long after any previous notifications there, was most puzzling. Extensive investigation, however, revealed that they were cases of chickenpox. Thus, a case in June in Upper Zaire appears to have been the last in the country, occurring just as the vaccination campaign concluded.

By the time this last case had occurred, Zaire's only infected neighbour was the Sudan, in which cases continued to occur in border areas until December 1972. No importations were detected in Zaire, despite continuing, intensive search by a specially assigned surveillance team headed by one of the WHO medical officers.

Data regarding the age and vaccination status are available for 2124 cases that occurred between 1969 and 1971 (Table 18.9).

The surveillance teams, with a staff of 95, continued to function until eradication was certified in Zaire in 1977, although international staff were gradually replaced by experienced Zairian counterparts. A special programme for the surveillance and investigation of monkeypox continued through 1986 (see Chapter 29).

Between 1971 and July 1976, nearly 700 specimens were collected, of which 3 (in

Table 18.9. Zaire: number of reported cases of smallpox, by age group and vaccination status, 1969–1971^a

Age group (years)	Cases		With vaccination scar	
	Number	% of total	Number	% of cases
<1	360	16.9	—	—
1–4	758	35.7	78	10.3
5–14	548	25.8	84	15.3
≥15	458	21.6	155	33.8
Total	2 124	100.0	317	14.9

^a Details are not available for 725 other cases of smallpox reported during this period; in addition, 2 incorrectly notified cases of chickenpox have been omitted from consideration.

1971) contained variola virus, 9 contained monkeypox virus, 88 contained viruses of the herpes–varicella group and 6 contained either vaccinia virus or tanapox virus (Table 18.10).

Eventually, the teams were successful in obtaining the cooperation of all but a few of the 3289 health establishments in performing vaccinations. A surprisingly large number of vaccinations were given (Table 18.11), especially after the surveillance teams began their regular schedule of visits in 1971.

As Dr Ziegler was to observe, many staff working in rural dispensaries had not been

Plate 18.5. A: The roads in Zaire varied widely in character, some consisting only of logs laid along forest paths. **B:** Communication between smallpox eradication headquarters in Kinshasa and the surveillance teams relied on 100-watt transceivers built into trailers. Garry Presthus, shown here, was the first WHO operations officer to be recruited. Later he served as a smallpox adviser in Botswana. ▷



A
Z. JEZEK



B
BY COURTESY OF G. PRESTHUS



WHO / J. G. BREMAN

Plate 18.6. Nomadic groups, who ranged widely over large areas of central and northern Sudan, sometimes carried smallpox over long distances. Here, a surveillance worker with a WHO smallpox recognition card questions a group about possible cases.

Table 18.10. Zaire: results of laboratory examination of specimens, 1971-1976^a

Year	Number of specimens examined	Laboratory diagnosis			
		Varicella virus	Monkeypox virus	Herpes-varicella virus	Vaccinia and tanapox viruses
1971	168	3	0	0	0
1972	138	0	3	11	2
1973	89	0	2	18	1
1974	53	0	1	15	1
1975	189	0	2	25	1
1976 (July)	54	0	1	19	1

^a Recorded according to the year of collection of the specimens; in Table 24.1 (Chapter 24), the specimens tested have been recorded according to the year of their receipt by WHO in Geneva.

Table 18.11. Zaire: number of smallpox vaccinations performed by health establishments, 1968-1975

Year	Number of vaccinations
1968	575 573
1969	3 574 245
1970	2 681 330
1971	2 869 222
1972	4 080 313
1973	4 960 815
1974	3 089 989
1975	2 562 752

Table 18.13. Zaire: receipt of weekly epidemiological reports, 1975-1976

Year	Quarter	Number of weeks	Number of reports expected	Reports received	
				Number	%
1975	1st	11	238	194	81.5
	2nd	12	238	183	76.9
	3rd	13	238	185	77.7
	4th	14	238	184	77.3
1976	1st	11	238	180	75.6
	2nd	12	238	193	81.1
	3rd	13	238	169	71.0
	4th	14	238	196	82.4

Table 18.12. Zaire: results of vaccination scar surveys, by age group and province, 1972 and 1974

Province	Percentage with vaccination scars (total number examined=505 802)			
	<1 year	1-14 years	≥15 years	
1972				
Bandundu	22	87	90	
East Kasal	20	78	77	
Equateur	26	89	96	
Kinshasa	65	95	97	
Kivu	20	86	88	
Lower Zaire	25	96	96	
Shaba	48	85	84	
Upper Zaire	47	95	99	
West Kasal	25	86	81	
Province	Percentage with vaccination scars (total number examined=61 633)			
	<1 year	1-4 years	5-14 years	≥15 years
1974				
Bandundu	56	84	96	98
East Kasal	34	85	96	99
Equateur	45	75	89	96
Kinshasa	81	100	94	94
Kivu	64	89	95	98
Lower Zaire	74	91	94	98
Shaba	66	88	96	95
Upper Zaire	66	90	98	99
West Kasal	32	85	93	96

visited by a physician or nurse for 10 years or more. They responded enthusiastically to the visits of the surveillance teams and many conscientiously undertook to sustain high levels of vaccinal immunity, not only among the people coming to their dispensaries but among the inhabitants of nearby villages as well. The results as measured by scar surveys in 1972 and again in 1974 confirm the success of this effort (Table 18.12).

Eventually 238 reporting sites were identified and charged with the responsibility of reporting weekly any suspected cases of smallpox and chickenpox. This network, which included 92 hospitals, 39 health centres, 54 dispensaries and 48 district or provincial health and medical units, ultimately served as a national morbidity reporting system. The response was remarkably good considering the difficulties of communication (Table 18.13).

During the surveillance period, the mobile teams with their transceivers provided a mechanism for the emergency reporting of outbreaks of other diseases, such as plague, yellow fever and cerebrospinal meningitis. Often the teams themselves participated in special programmes to control these outbreaks.

SUDAN

Background

The Sudan, even larger in area than Zaire, was no less important geographically to the strategy of the eradication programme—but for different reasons. Following a mass vaccination campaign conducted during 1961–1963, the Sudan became free of smallpox and is believed to have remained non-endemic until 1968. However, the risk of the disease being imported into the country and becoming re-established was high. Traditional caravan routes between Mecca and the endemic countries of western Africa crossed the north-central area of the Sudan and, historically, many outbreaks had been traced to cases imported by such travellers. To the east lay heavily endemic Ethiopia, whence came some 200 000 seasonal labourers each year for the harvesting of *dura* (sorghum). In addition, because of civil war in northern Ethiopia, thousands of refugees from Eritrea had moved across the Sudan's north-eastern borders, many of them returning periodically to Ethiopia. In the southern part of the Sudan, a civil war had been in progress since 1956 and many refugees frequently travelled between the Sudan and camps in Uganda and Zaire.

In 1967, the Sudan expressed interest in participating in the smallpox eradication programme, the principal component of which would be a campaign during which, as in Zaire, BCG vaccine would be administered at the same time as smallpox vaccine. The programme, however, did not begin until 1969 and proceeded slowly thereafter, the logistics of administering the two vaccines at the same time never being satisfactorily worked out.

Meanwhile, 9 cases of smallpox thought to be importations occurred in 1967, and during the first few months of 1968, 104 cases were detected. Investigation suggested that they were attributable to an importation from Ethiopia. No cases were discovered after June and it was thought that the outbreak had been satisfactorily contained. However, cases were again detected in December 1968 and in the early months of 1969 in many of the same areas. Once more, special investigations were undertaken. In all, 119 cases were documented but it was believed that there were many others which had not been detected. Although the initial outbreaks had occurred near the Ethiopian border, it was clear that

many had originated in rural areas of the southern Sudan, unreachable because of civil war. It was suspected that endemic smallpox had become re-established and, in 1970, this became a certainty as the disease spread widely across the country.

Repeated attempts had been made to persuade WHO advisers and senior Sudanese staff that a continuing programme of surveillance and containment was vitally important in a country which was thought to be smallpox-free, but little was done until 1972. A seminar held in December 1971 marked a turning-point. A Sudanese medical officer, Dr Omer Sulieman, rapidly organized a surveillance–containment programme in the north, beginning in January 1972. In April, he moved to the south on conclusion of the civil war. Working with extraordinary energy and skill, he and Sudanese programme staff stopped transmission in December 1972. Subsequently, programme staff conducted a thorough search and vaccination campaign over extensive areas along the Ethiopian border in collaboration with Ethiopian staff, and at times assisted the programme in Ethiopia through search and case investigation far inside the frontiers of that country.

There was some speculation that the Sudan had never been smallpox-free, that transmission had always continued in inaccessible areas of the war-torn southern provinces. In retrospect, however, the epidemiological data strongly support the belief that transmission in the Sudan was interrupted in 1962 and endemic smallpox did not recur until after the importations of 1967–1968.

Population Movements

The Sudan is diverse in character, with extensive desert throughout the north giving way to steppe and grassland in the central part of the country and to large marshes and tropical forest areas in the south-eastern and southern parts of the country. The White Nile extends the length of the country, some 2000 kilometres, providing river transport and irrigation in the east central region. It is joined at Khartoum, the capital, by the Blue Nile, which flows from Ethiopia. Nearly half of the Sudan's 12.9 million population (in 1967) live in the fertile, extensively irrigated areas of Khartoum, Kordofan and Blue Nile Provinces near the confluence of the two rivers (Fig. 18.6).



Fig. 18.6 Sudan: movement of refugees and seasonal populations.

The seasonal migration of agricultural workers was a significant factor in the spread of smallpox within the country and in the importation of the disease from Ethiopia. South of Khartoum were the great cotton fields of the Gezira Irrigation Scheme, which employed some 350 000 workers between mid-December and May. The labour force consisted largely of Sudanese workers recruited in various provinces and transported in large groups to and from the area by truck and boat. As important were the *dura* fields in Kassala, Blue Nile and Upper Nile Provinces, which attracted some 400 000 seasonal labourers, most of whom were employed for the harvest during December–February. Half of the workers came from Ethiopia, many of them travelling on foot for as long as 2–3 weeks to reach the area.

Other factors contributed to the movement of population and the spread of smallpox. Some 1.5 million pastoral nomads roamed the central and northern regions of the Sudan. In the north-east, upwards of 100 000 Ethiopian refugees from Eritrea camped near border areas but moved in and out of the country. Additionally, each year 30 000–40 000 pilgrims to Mecca from western Africa travelled

across the country, through Khartoum. Population movements, overall, were far more extensive than in other Saharan and sub-Saharan African countries.

Civil war in the 3 southernmost provinces, which began at the time of independence in 1956, when tribal populations revolted against traditional leadership, was another serious problem. An estimated 50 000–100 000 Sudanese refugees from Equatoria Province lived in northern Uganda and Zaire but regularly moved in and out of the Sudan. Until March 1972, when a peace treaty was signed, much of the rural area in these southern provinces could be penetrated only by military convoy; health activities, including smallpox vaccination, were few; roads and bridges were destroyed or deteriorated.

Health facilities were reasonably numerous in the Sudan, although in a country so large they were widely dispersed. A tabulation drawn up in 1976 listed 127 hospitals, 159 health centres, 590 dispensaries and 1214 dressing stations.

Smallpox in the Sudan before 1968

Records of cases of and deaths from smallpox have been available since 1925. Up to the end of 1958, these show case-fatality rates in most years of 10–20%, with between 12 and almost 6500 cases reported each year. Major outbreaks occurred sporadically, the last being recorded during the period 1952–1955 in Darfur Province and the 3 southern provinces. Mass vaccination campaigns were conducted whenever outbreaks developed. Each year, 500 000–2 000 000 persons were vaccinated with liquid vaccine produced at a laboratory in Khartoum. Routine vaccination was rarely performed by the health units but enough persons were being vaccinated in mass campaigns to discourage the practice of variolation, which had once been widely prevalent.

In 1959 case-fatality rates abruptly declined (Table 18.14), falling to levels typical of those of variola minor. Since most of the cases during that year and the 3 subsequent years were recorded in Blue Nile Province, adjacent to Ethiopia, it is probable that the virus strain originated in that country.

Following the decision of the Twelfth World Health Assembly, in May 1959, to carry out global smallpox eradication, the Sudanese government requested assistance

Table 18.14. Sudan: number of reported cases of and deaths from smallpox, and case-fatality rates, 1952-1972

Year	Number of cases	Number of deaths	Case-fatality rate (%)
1952	3 670	578	15.7
1953	3 030	221	7.3
1954	4 200	584	13.9
1955	1 427	284	19.9
1956	25	4	16.0
1957	295	23	7.8
1958	380	90	23.7
1959	336	9	2.7
1960	162	0	0
1961	8	0	0
1962	95	0	0
1963	0	0	0
1964	0	0	0
1965	69	9	13.0
1966	0	0	0
1967	9	0	0
1968	106	0	0
1969	130	0	0
1970	1 051	15	1.4
1971	1 141	10	0.9
1972	827	10	1.2

from WHO to undertake a national vaccination campaign. WHO provided US\$12 000 for vehicles and refrigerators and the USSR contributed freeze-dried vaccine. Except for this support, the programme was entirely a national effort, utilizing temporary staff who vaccinated by house-to-house visits and, in some areas, at collecting points. The transport provided by WHO was supplemented by rented vehicles and some provided by the military. During a 3-year period (1962-1964) 8 840 152 vaccinations were performed, a number equivalent to about 75% of the total population. The central and northern provinces were much better vaccinated than the 3

war-ridden southern provinces: in Upper Nile and Bar el Ghazal Provinces the coverage was very limited and in Equatoria Province it was nonexistent.

Although many persons remained unvaccinated, the campaign was successful in controlling smallpox. Except for an outbreak of 69 cases in Darfur Province in 1965 and 9 cases in 1967, no cases were reported in the Sudan during the years 1963-1967. Following the mass campaign, the numbers of vaccinations again fell off, averaging just 500 000 per year from 1964 to 1967, and because liquid vaccine was again employed, it is probable that only a small proportion were successful.

The Decision to Undertake an Eradication Programme, 1967

Because so few people were vaccinated after 1964, it was assumed in 1967 that few of those under the age of 5 years had ever been successfully vaccinated and that large numbers throughout rural areas of the southern provinces remained susceptible. No cases were being detected by staff of the comparatively extensive infrastructure of health services but concern was expressed that smallpox, if imported, might recur in epidemic form. Accordingly, it was decided in June 1967 to undertake another 3-year national vaccination campaign, and Dr Abdel Hamid El Sayed Osman was placed in charge. The inhabitants of provinces in the central region (Table 18.15) would be vaccinated first, followed in the second year by those of the

Table 18.15. Sudan: population and number of reported cases of smallpox, by region and province and by year, 1966-1973

Region and province	Population, 1970 ^a (thousands)	Number of cases							
		1966	1967	1968	1969	1970	1971	1972	1973
Northern region:									
Northern	912	0	0	0	0	2	1	0	0
Kassala	1 450	0	0	9	0	89	281	111	0
Khartoum	1 066	0	7	2	7	261	22	7	0
Central region:									
Blue Nile	3 481	0	0	19	35	195	252	13	0
Kordofan	2 010	0	0	0	0	67	17	55	0
Darfur	1 991	0	0	0	0	0	17	5	0
Southern region:									
Upper Nile	690	0	2	76	76	106	78	1	0
Bahr El Ghazal	1 275	0	0	0	0	177	316	216	0
Equatoria	729	0	0	0	12	154	157	419	0
Total	13 604	0	9	106	130	1 051	1 141	827	0

^a Estimates based on official government data, 1973.

Table 18.16. WHO support and national contribution to the Sudan programme, 1967-1976 (US\$)^a

Year	WHO support			Government contribution
	Personnel	Supplies, equipment and local costs ^b	Total	
1967	18 709	104 213	122 922	272 832
1968	18 638	52 323	70 961	459 506
1969	40 810	19 446	60 256	746 697
1970	47 261	5 523	52 784	1 148 765
1971	44 669	34 140	78 809	1 005 169
1972	31 089	24 453	55 542	1 076 967
1973	18 664	34 108	52 772	1 134 406
1974	19 913	56 750	76 663	1 005 169
1975	46 002	84 039	130 041	1 522 114
1976	87 726	—	87 726	1 636 990
Total	373 481	414 995	788 476	10 008 615

^a Based on WHO financial records and SME/78.13, Government of the Sudan.

^b Excluding the cost of 16 635 000 doses of vaccine.

provinces in the northern region. By that time it was hoped that the civil war in the southern provinces would have ceased, permitting operations to be conducted there. This initial vaccination of the population of the central provinces could help to ensure high levels of immunity in the agricultural areas, which received large numbers of migrant labourers, and thus serve to prevent the possible spread of smallpox to the northern provinces. However, little attention was given to the development of a reporting system or of a mechanism for the investigation of suspected cases.

WHO support was greater than during the earlier campaigns (Table 18.16) and this time included the services of a WHO adviser. Commitments of the Sudanese government were substantial and included a staff of 539 persons.

It was expected that transport and supplies would arrive in the autumn of 1967, thus permitting the programme to begin towards the end of the year. In 1967, however, war between Egypt and Israel closed the Suez Canal, and supplies and equipment had to be rerouted around the Cape of Good Hope. What with the longer journey and the chaos in shipping, the supplies did not arrive until early 1969. Meanwhile, freeze-dried vaccine was supplied by WHO for use by health service units. However, as in other countries, very few vaccinations were performed.

Smallpox is Reintroduced into the Sudan

The first of what were thought to be imported outbreaks occurred in Khartoum in

July 1967, when 4 cases of smallpox were discovered whose source of infection was not identified. Because of the outbreak, a mass vaccination campaign was conducted in and near the city over a 3-week period, during which 717 904 persons were vaccinated. As expected, it was found that few children under 5 years (17%) had been vaccinated previously. In December, another outbreak of 5 cases occurred in Khartoum among Ethiopians from Eritrea, but smallpox did not spread among the now well-vaccinated population.

Beginning in February 1968, more outbreaks began to occur but little is known about their source or true magnitude. The importance of surveillance and containment measures was not then appreciated in the Sudan. In February, a patient from Kordofan Province developed smallpox in Khartoum, the probable source being vaguely identified as a market in Darfur Province. Smallpox was not known to be present in Darfur but no investigation was conducted. However, a mass vaccination campaign was organized in Kordofan during which 801 778 persons were vaccinated. In March, another case was recorded in Khartoum but its origins were not investigated.

WHO staff both in Geneva and in the Regional Office for the Eastern Mediterranean were alarmed by the occurrence of smallpox in a country which was thought to be free of the disease and anxiously sought additional information from the government and from the WHO smallpox adviser assigned to the Sudanese programme, but to no avail. In April 1968, cases began to be reported in Upper Nile Province as well. Dr Ehsan Shafa, the WHO Regional Adviser on Smallpox Eradication, was concerned about the situation and spent 2 months investigating outbreaks in this area and organizing mass vaccination campaigns. The first case was thought to have developed in December 1967, shortly after the infected person had arrived from Ethiopia. From there smallpox appeared to have spread to 10 other localities in Upper Nile Province. Subsequently, cases occurred in 3 areas which were 600 kilometres to the north, 1 area in Kassala Province and 2 in Blue Nile Province (Fig. 18.7), but their sources of infection were not identified. In all, 76 cases were detected in Upper Nile Province, the last on 16 May 1968. The discovery that the first known outbreak originated in Ethiopia, and that other outbreaks followed

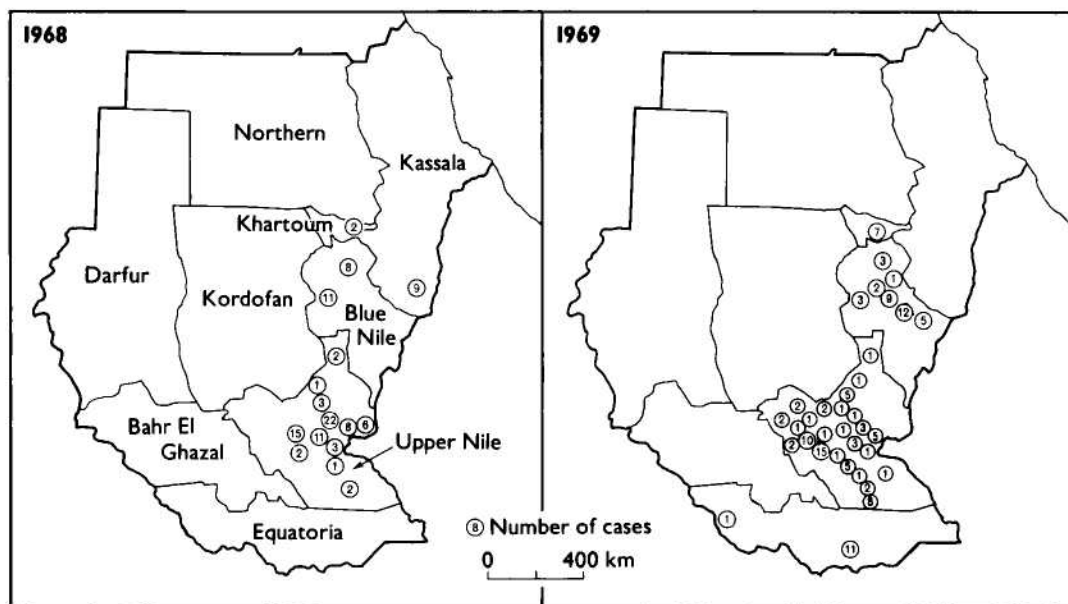


Fig. 18.7. Sudan: geographical distribution of reported cases of smallpox, 1968–1969.

in a temporal sequence moving from south to north, suggested that the series of outbreaks had originated from an importation with subsequent spread in a country otherwise free of smallpox.

To control the early 1968 outbreaks, mass vaccination campaigns were conducted in April and May: 452 256 persons were vaccinated in a single month in Upper Nile Province, 23 005 in Kassala Province, and 638 015 in Blue Nile Province—in all, more than a million people. Few vaccinations had been performed in Upper Nile Province during the 1961–1963 campaign, and the 1968 campaign reflected this. Of those aged 1–4 years, 72% received primary vaccination, as did 61% of the whole population. Primary vaccinees accounted for only 24% of the total in Kassala Province and for only 18% in Blue Nile Province. The last cases in these outbreaks were detected in June. Over the next 5 months, no further cases were reported (see Fig. 18.8).

The National Mass Vaccination Campaign is Launched, 1969

Considering the size of the country and the extensive movement of population in the Sudan, it was recognized that an effective

mass vaccination campaign would be a challenge. Favouring its success, however, was the fact that the country's infrastructure of health services was among the best developed in Africa; maps and demographic data were available for most districts and council areas; and health units were widely dispersed. Moreover, a national vaccination campaign had been completed less than 5 years earlier. However, from its inception, the campaign experienced an array of problems. In mid-1968, 190 vaccinators were appointed, trained and posted to the central provinces. Within a short period, most resigned and returned to Khartoum, having found it difficult to cope with field conditions and having encountered resentment by the villagers, who were accustomed to locally recruited vaccinators. New staff were recruited and trained, of whom a greater proportion were from the provinces to be vaccinated, and in January 1969 field operations began.

The staff of 539 was substantially greater, in proportion to population, than in other African countries, in part because of the government's decision to provide BCG vaccine at the same time as the smallpox vaccine. Superficially, this appeared logical, but in practice it presented special problems. Smallpox vaccination in the Sudan was customarily performed by vaccinators proceeding from

house to house, the assembly of large numbers of people at collecting points not being well accepted in most areas. Because of this, jet injectors were not useful. Although smallpox vaccination, administered with the bifurcated needle, was well suited to house-to-house vaccination, BCG vaccination, which required the use of a needle and syringe, was not. Among the problems was that the needles had to be flamed after each inoculation and the syringes repeatedly refilled from the vaccine vial. Accordingly, BCG vaccine was customarily administered at assembly points. To the smallpox staff, it appeared impracticable to try to combine a house-to-house vaccination campaign with one which called for the gathering of children at a collecting point, but the government, supported by the WHO Regional Adviser for Tuberculosis, decided on the combined programme. Unfortunately, the operational problems were never resolved.

For the campaign, 30 vaccination units were constituted, approximately 10 for each of 3 provinces (Blue Nile, Darfur and Kordofan), each unit comprising 6 smallpox and 3 BCG vaccinators plus supervisors. The units moved systematically through the province. The smallpox vaccinators went from house to house; the BCG vaccinators worked at a collecting point, vaccinating those up to 20 years of age. Each group prepared a separate set of records listing the name of the head of each household, the number of residents by age group and the number of vaccinations performed. Thus, two sets of forms were prepared in each village; no effort was made to reconcile them and, in fact, the records were not subsequently used either in assessment or in follow-up vaccination.

The plan for assessment of vaccination coverage and take rates was likewise inefficient. It called for a separate assessment team to examine one-quarter of those residing in 50% of the villages after 1 week. This involved much more travel and manpower than the standard plan proposed in the 1967 WHO *Handbook for Smallpox Eradication Programmes in Endemic Areas* (SE/67.5 Rev.1), which suggested that 5–10% of the villages should be assessed.

Progress was slow. Smallpox vaccinators averaged only 25–35 vaccinations a day in 1969 and 40 a day in 1970. Those performing BCG vaccinations averaged somewhat less than half this number. Overall, productivity was one-tenth to one-third that of other programmes in Africa.

Recurrent Epidemic Smallpox, December 1968

While national and WHO staff struggled with the logistics of initiating the vaccination campaign, cases of smallpox once again began to be reported in late December 1968 in Upper Nile Province. A surveillance team had not yet been constituted and so 2 WHO staff members were again sent temporarily to the Sudan to investigate. From their observations, it was apparent that smallpox had re-established itself in the country. The initially reported cases had occurred in villages near the Ethiopian border. The outbreak had spread westwards and northwards just as had happened earlier in 1968. However, careful epidemiological investigations suggested that this was not an importation from Ethiopia followed by localized spread, but rather the spread of smallpox from a number of endemic areas within the Sudan itself (*Wkly epidem. rec.*, 1969b). By the end of April 1969, the team had documented 119 cases in 4 provinces—Upper Nile, Blue Nile, Equatoria, and Khartoum. The beginning of the outbreak coincided with the beginning of the harvest season, when large numbers of seasonal workers began to travel from Upper Nile and Equatoria by boat, truck, train and on foot. Most of the cases were detected in special camps established for seasonal workers and at check-points for those in transit. It was clear that there were many more cases in villages, some in the southern areas afflicted by civil war, but in the absence of an organized reporting system, they were not being notified. The cases were of the mild variola minor type, only 3 deaths occurring among 119 patients. (These deaths are not recorded in the official figures given in Table 18.14.) Many patients were able to travel even when ill and thus readily disseminated the disease. The fact that half of all the cases were in persons over 15 years of age and that more men than women were affected (Table 18.17) reflected the spread of smallpox primarily among migrant labourers.

The investigators recommended that a surveillance programme should be established and a special campaign mounted to vaccinate seasonal workers in and *en route* to their camps. They believed that little could be done to vaccinate those in the southern provinces, but they reasoned that if the seasonal workers were well immunized, vaccinal immunity in sparsely settled rural areas of the south would

Table 18.17. Sudan: number of reported cases of smallpox, by age group and sex, January–April 1969

Age group (years)	Male	Female	Total	% of total for all ages
<1	2	1	3	3
1–4	14	13	27	24
5–9	7	7	14	12
10–14	5	7	12	10
≥15	38	21	59	51
Total	66	49	115	100

be increased and, conceivably, the disease might die out.

The recommendations were not implemented but, as during the preceding year, the number of reported cases diminished; between the beginning of June and the end of November 1969, only 2 cases were notified (see Fig. 18.8).

Major Epidemics Begin, 1970

In Upper Nile Province 2 cases were reported in December 1969, 3 cases in January 1970, and 124 in February. Smallpox was also introduced into the northern Sudan from Ethiopia. Steadily the disease spread across the country to infect all but Darfur Province. In June 1970, a central surveillance team was appointed under the direction of Dr Sulie-man, and by the end of the year, 1051 cases had been documented; most were detected by the surveillance team. Interestingly, adult cases continued to predominate, 55% being in persons over 15 years of age.

The vaccination campaign continued to progress slowly, its pattern of operation unchanged, as neither Sudanese nor WHO staff seemed able to devise an alternative operational approach. Continuing assessment showed that when vaccination had been completed in an area, consistently more than 85% and usually more than 95% of those under 5 years of age had a smallpox vaccination scar. Among older children and adults, the proportions were even higher, reflecting past vaccination efforts. BCG vaccination coverage, however, was usually in the range of 60–75% and sometimes lower. WHO regional smallpox eradication staff urged that BCG vaccination should be suspended until smallpox transmission had been interrupted, but, to the government, the policy of providing two vaccines simultaneously remained an

attractive one. The smallpox eradication staff turned for advice to the WHO Regional Adviser for Tuberculosis, who had originally advocated the plan. Unhelpfully, he concluded in his report: "Certainly, the least attractive approach would be to continue the *status quo*, that is smallpox vaccination from house to house and BCG vaccination at collecting points." He offered no alternative plan, concluding only with the advice: "Whatever the final solution, one should test-run the various approaches as envisaged... and select the most promising one."

By June 1970, 18 months after the programme had begun, only 5.3 million persons had been vaccinated, an estimated 68% of the population in the 3 provinces in which operations had been expected to be completed during the first year of the programme. Outside of these 3 provinces, the number of vaccinations recorded was equivalent to 5% or less of the population.

At the end of August, the programme stopped altogether when cholera cases were detected in the Sudan and the Ministry of Health decided to assign the teams to conduct a mass cholera vaccination campaign. Cholera vaccine offered little protection but was widely used nevertheless in many countries at that time. During November, no smallpox or BCG vaccinations were performed and, for many months thereafter a considerable number of teams and vehicles continued to be used for the administration of cholera vaccine. During December 1970, the smallpox–BCG vaccination campaign was gradually resumed but, as was noted in the populous Blue Nile Province, many villagers had left by that time to pick cotton. Entire villages were found empty or with very few residents. Vehicles were in critically short supply, some having been irreparably damaged by the bad roads, some remaining with cholera vaccination teams and some having been diverted to other uses by the Ministry of Health. In March 1971, the mass campaign finally concluded in the central provinces, more than 2 years after it had begun. The number of vaccinations reported to have been performed during 1969–1970 was greater than in 1968 (Table 18.18), but not commensurate with that expected of a staff of more than 500.

The vaccination campaign shifted to the northern provinces in 1971 and coincidentally the surveillance programme—such as it

Table 18.18. Sudan: number of reported vaccinations, 1968-1975

Year	Number of vaccinations
1968	1 967 450
1969	3 404 587
1970	4 871 573
1971	2 376 038
1972	2 268 142
1973	1 944 700
1974	1 121 693
1975	942 068

was—ceased when Dr Sulieman was re-assigned to organize the vaccination campaign in Kassala Province. The WHO regional office replaced the WHO smallpox adviser by another adviser who, like his predecessor, was an ardent proponent of mass vaccination, with no understanding of the importance of the surveillance-containment strategy despite intense efforts at persuasion by the WHO regional office and Headquarters staff. The contributions of these advisers to the field programme were further compromised by the fact that neither travelled frequently out of Khartoum.

By the autumn of 1971, smallpox transmis-

sion in Africa had been interrupted in all but 3 countries: Ethiopia, in which the programme had only just begun; Botswana, which had become reinfected that summer following an importation from South Africa; and the Sudan, whose programme was then in its fifth year. Cases in the Sudan were being reported from all provinces, although of greatest concern were the 3 in the south, in which no formal smallpox programme activities were being conducted and from which 55% of all cases were then being reported. Some cases in Uganda were also traced to this area.

To assess what, if anything, could be done, Dr Shafa, then assigned to the WHO Smallpox Eradication unit in Geneva, visited the southern provinces in late October. He determined that movement out of the main towns was restricted but convoys regularly travelled to various areas, including the health establishments, which, for a population of 2.5 million, were quite numerous (Table 18.19). None held stocks of smallpox vaccine. None reported smallpox cases regularly, but all stated they could readily do so by utilizing police and army radio. It was apparent that vaccination and the investigation of outbreaks were impossible in rural areas, but



D. P. FRANCIS

Plate 18.7. A provincial smallpox eradication office in the northern Sudan in September 1973. By that time the programme had been reorganized primarily as a surveillance operation.

Table 18.19. Southern Sudan: number of health establishments, by category and province

Province	Hospitals	Dispensaries	Dressing stations
Upper Nile	5	38	42
Equatoria	5	19	38
Bahr El Ghazal	7	12	54
Total	17	69	134

much could be done in the main towns and in districts adjacent to health units. Learning that a year earlier cholera vaccine had been successfully administered throughout the area with the help of police and army personnel, Dr Shafa proposed that vehicles, vaccine and other necessary supplies should be sent to the south, and that personnel from the southern provinces, then working in the mass vaccination campaign in the north, should be transferred to staff surveillance teams. Vaccine was sent to the south but the smallpox eradication programme leadership remained preoccupied with the mass vaccination campaign in the north and little else was done.

The Initiation of an Effective Surveillance-Containment Programme, 1971

As viewed by WHO Headquarters staff, the critical problem for the Sudan lay in establishing an effective surveillance and containment programme. For this to be done without the support of senior programme staff or the WHO adviser seemed unlikely. Nevertheless, more in despair than in hope, it was agreed



D. P. FRANCIS

Plate 18.8. Omer Sulieman (b. 1940) organized a central surveillance team in the Sudan in June 1970 which was disbanded in March 1971, when mass vaccination began in the northern provinces. He re-established a surveillance programme in January 1972 and transmission ceased by the end of the year. Subsequently, he was recruited by WHO and served as smallpox eradication adviser in Pakistan.

that a special seminar on surveillance would be conducted in December 1971 for physicians and senior sanitary inspectors in each province. Hope was expressed that some way might be found for Dr Sulieman again to be given responsibility for supervising surveillance activities. Replacement of the WHO adviser was proposed but the WHO regional office disagreed. However, the addition of a

Vaccination Conducted by the Anyanya Resistance Movement

In 1970, WHO staff in Geneva were asked for vaccine by representatives of the Anyanya Resistance Movement, the rebel forces in the southern Sudan. They denied that smallpox was present in the area but were concerned that epidemics might occur. When asked how they could transport the vaccine, they indicated that they regularly took supplies north by road from Kampala, the capital of Uganda, and from there travelled on foot for 7–10 days into forest areas of the southern Sudan. Government staff could not reach these areas but, officially, WHO could provide vaccine only to Member governments. It was a quandary because, clearly, it was in everyone's best interest for this area to be better protected.

The dilemma was resolved by transferring vaccine to leaders of the resistance movement and recording the amount as "lost from inventory". Whether or not it was used properly was unknown until after March 1972, when the civil war ended. Sudanese staff found on investigation of outbreaks that the Anyanya had conducted quite extensive vaccination campaigns although, as they pointed out, many persons remained unvaccinated.



E. SHATA

Plate 18.9. Migrants crossing the White Nile River at Juba in the southern Sudan. Civil war in the southern provinces resulted in a flow of refugees into Uganda and Zaire, who nevertheless frequently returned to trade or to visit relatives. They were the source of many importations of smallpox into Uganda between 1969 and 1972.

second WHO adviser was accepted provided that WHO Headquarters could find the necessary funds.

To the surprise of all concerned, the December seminar proved to be the turning-point. As Dr Sulieman later observed, he appreciated for the first time how important surveillance and containment really were. Following the seminar, and over the objections of the WHO adviser, he resumed responsibility for the surveillance programme. With a remarkably imaginative and energetic group of public health officers serving as directors of provincial surveillance teams, he began to strengthen reporting, to search for cases and to investigate outbreaks throughout the central and northern provinces. Many outbreaks were discovered and contained. Where resistance to vaccination was encountered, vigorous measures were taken. For example, cooperation was poor in one village in Kordofan; the police surrounded it before sunrise, and vaccinators moved from house to house and room to room, searching and vaccinating. By April, virtually all cases were occurring among

travellers from the south, and in June the last cases were detected in the central and northern provinces.

At the end of March 1972, the government and the southern rebel forces—the Anyanya Resistance Movement—signed a treaty of reconciliation. In May, Dr Sulieman transferred his headquarters, including personnel and vehicles, to Bahr El Ghazal to begin work in the south. The rainy season was under way and travel in rural areas was difficult; in some it was impossible until October. In the latter areas, this period was used to construct detailed maps of the routes followed by migratory workers. An order was issued requiring all health units to report cases weekly; all chiefs, subchiefs, police stations, schools, forest and road workers were contacted and asked to report cases to these centres. Work was begun with 44 health staff who undertook a rapid house-to-house search throughout accessible areas.

Vaccination was performed only where outbreaks were encountered. By means of a scar survey, staff discovered that in most towns and villages along the way, 90% or

more of the population had been vaccinated. The cases found in these areas were generally on the periphery of towns and were quickly contained. However, many persons had moved deep into the jungle during the war. There, vaccinal immunity was far lower and rumours of outbreaks were difficult to trace. Accordingly, former Anyanya military personnel were recruited and given bicycles to search for cases in remote areas—areas well known to them. Returning refugees were vaccinated at resettlement camps; health units throughout the 3 provinces were given supplies of vaccine and instructed to vaccinate both those attending centres and others living nearby. In June 1972, the programme was extended to Equatoria and Upper Nile Provinces. By the end of September 1972, 17 outbreaks had been discovered in Bahr El Ghazal, 10 in Equatoria and 1 in Upper Nile. Surprisingly, the largest of these consisted of only 25 cases. The cooperation of those living in the area was illustrated by the fact that in Equatoria, the last 2 outbreaks were reported by a villager and a chief who, respectively, walked 45 and 70 kilometres to report cases. In October, the rains stopped and the systematic search was extended throughout the rural areas. Teams travelled on northward-bound river steamers to search for cases and to vaccinate embarking passengers, and other check-points were established. Fifty medical students from the School of Medicine in Khartoum joined the programme, working in teams with vaccinators to search for outbreaks and to contain them. Only 5 additional outbreaks were discovered in Bahr El Ghazal Province and 1 in Upper Nile Province, although numerous patients were found who

had experienced the onset of illness many weeks previously. Fig. 18.8 shows the number of cases of smallpox by week of report and by week of onset. Interestingly, the last case was discovered on 17 December 1972 in a village called "Malek", which is the local name for smallpox. One additional patient who had been infected in Ethiopia developed smallpox on 23 December in northern Kassala Province but he was the last.

On Dr Shafa's recommendation, a former operations officer from the Ethiopian programme, Mr James Lepkowski, and a former medical officer from the western Africa programme, Dr Donald Francis, were assigned by WHO to Juba in Equatoria Province in November 1972 and January 1973 respectively. A thorough systematic search for cases was organized throughout the southern provinces and subsequently in areas bordering on Ethiopia. It seemed inconceivable that transmission had been stopped throughout such a vast area, in which, less than a year before, smallpox had been reported from all provinces. However, no cases could be found (WHO/SE/73.60, Lepkowski et al.; WHO/SE/74.67, Bassett et al.). During the course of a single year, Dr Sulicman had brought order out of chaos and had succeeded in stopping transmission before additional manpower from WHO had had time to arrive on the scene. In September 1973, a village-by-village search was conducted throughout the country, but again no cases were found.

Smallpox remained widely prevalent in Ethiopia, however, and, as previously noted, many people travelled between the Sudan and Ethiopia. Special surveillance units were posted to migrant labour and refugee camps,

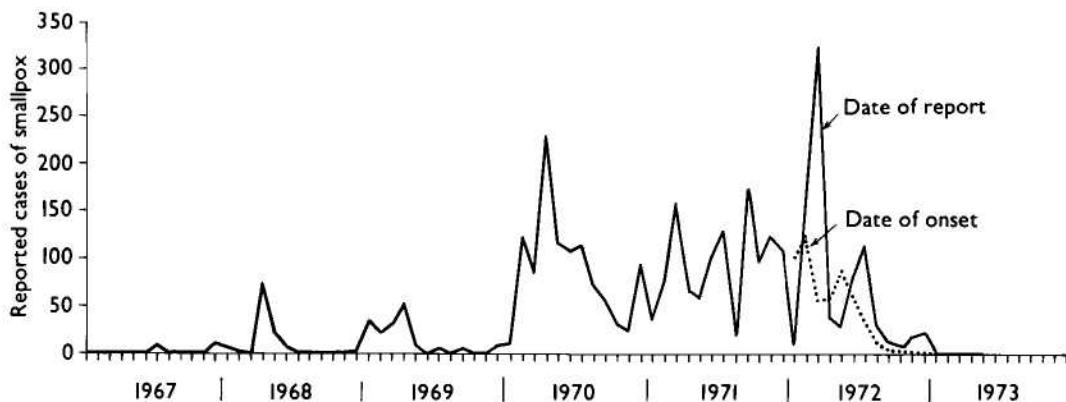


Fig. 18.8. Sudan: number of reported cases of smallpox, by month, 1967–1973, with cases plotted according to week of report and week of onset for 1972.



Plate 18.10. Donald P. Francis (b. 1942), an epidemiologist, was the WHO smallpox eradication adviser in the Sudan from January 1973, arriving just after the occurrence of the last known case in the country. With the Sudanese staff, he helped to organize a national surveillance system to protect against the effect of importations of smallpox from Ethiopia.

search workers were assigned to travel on the river steamers and special search teams covered the border areas. Many rumours of cases were received, but none proved to be smallpox. In September 1972, during a seminar in Addis Abeba, it was proposed that Sudanese and Ethiopian teams should be granted permission to cross the border without hindrance when undertaking search operations. Both governments agreed and, thereafter, Sudanese teams investigating rumours of cases, sometimes at the request of Ethiopian programme officers, travelled far into Ethiopia. In November 1973 and in March 1974, the teams undertook special search and vaccination programmes over extensive areas, difficult of access, in Ethiopia.

Table 18.20. Sudan: results of vaccination scar survey, by age group and province, 1975-1976

Region and province	Number examined	Percentage with vaccination scars			
		<1 year	1-4 years	5-14 years	≥15 years
Northern region:					
Kassala	15 657	86	84	97	94
Central region:					
Blue Nile	12 047	55	72	90	90
Darfur	6 789	67	60	82	81
Kordofan	601	78	88	91	95
Southern region:					
Upper Nile	3 148	29	75	77	94
Equatoria	2 930	77	88	82	98
Bahr El Ghazal	6 438	15	25	75	71

The level of vaccinal immunity attained in the Sudan had been assessed in the central and northern provinces and found to be uniformly high, although doubt was expressed whether the surveys had been properly conducted. Not until 1975-1976 was a reliable cluster sample survey performed. It was found that coverage, in general, was high except in Bahr El Ghazal, in which systematic mass vaccination had not been conducted (Table 18.20).

The age and sex distribution of cases in the Sudan in 1970 was most unusual in that nearly half of all cases for which data are available were in adults, of whom 60% were male (Table 18.21). A large proportion of the recorded cases that year occurred among adult migrants coming from endemic areas in the south and in labour camps. As the disease continued to spread in the north, larger proportions of children were affected. Finally, in 1972, as cases in southern endemic areas were investigated, more cases were found in children, and the age distribution more nearly approximated to that found in other endemic areas: 15% of patients were under 5 years of age, and 48% were aged 5-14 years.

Table 18.21. Sudan: number of reported cases of smallpox, by age group and sex, 1970-1972^a

Age group (years)	1970				1971				1972			
	Male	Female	Total	(%)	Male	Female	Total	(%)	Male	Female	Total	(%)
<1	8	8	16	(2)	22	12	34	(3)	11	14	25	(5)
1-4	77	64	141	(15)	116	90	206	(19)	45	11	56	(10)
5-14	112	140	252	(27)	206	174	380	(36)	174	91	265	(48)
≥15	337	178	515	(56)	259	188	447	(42)	114	92	206	(37)
Total			924	(100)			1 067	(100)			552	(100)

^a Data not recorded for 127 cases in 1970, 74 cases in 1971, and 275 cases in 1972.

Investigation of a Suspected Case

The problems of travel are well illustrated by extracts from a report of the investigation of a case by Dr Satnam Singh, a WHO epidemiologist in the Sudan. On 10 September 1975, the smallpox programme office was notified of a suspicious rash in a 40-year-old woman seen at a dispensary in the village of Geissan, on the border of the Ethiopian region of Gojam, where many cases of smallpox had been occurring. Because of drought in their own country, many Ethiopians had begun to visit Geissan to obtain sorghum. The report stated that the patient had been isolated and 12 family members vaccinated as well as 980 residents and visitors in the village. The report had been delivered to the nearest telegraph station, Damazien, 156 kilometres away, after a 5-day journey on foot. The telegraph line being out of order, it was not until 9 September that the provincial medical officer received the message. He then telephoned in the report.

A sanitarian, Mr Abdul Gadir El Sid, joined Dr Singh on the first available flight to Damazien on 13 September. There the Assistant Commissioner provided them with a 4-wheel-drive all-terrain vehicle (a UNIMOG) and a 4-wheel-drive army vehicle for a trip expected to take 10–15 hours. They were accompanied by smallpox eradication workers and a few army personnel. As Dr Singh wrote: "From the moment we left Damazien, we realized it would be difficult to traverse the water-logged muddy track overgrown with 12-foot-high grass. Regularly, the army vehicle, despite its more powerful engine, got stuck in the sticky mud and had to be pulled out manually, aided by cables attached to the UNIMOG. The multiple running streams (*kbors*) that criss-crossed the track along the west bank of the Blue Nile caused additional delays. Some required reconnaissance on foot above and below the track to find a suitable crossing and the same was done when the regular track was waterlogged for long stretches. Detours were made through the tall grass fields and bushes. After one and one-half days' travel and a one-night halt, we had only covered a quarter of the distance and found ourselves with only the UNIMOG operational—the other vehicle having been irreparably damaged. It was decided that a few should return to Damazien to mount another expedition including a tractor.

"The return journey to Damazien was worse for it had rained in the meantime. After a one-night halt in a village, we reached Damazien at 9:00 p.m. on 16 September . . . and on the 18th we started for Geissan with one tractor, the same UNIMOG and a relatively new army vehicle with a mechanic and spare parts.

"To have a tractor was a boon. The vehicles when stuck were pulled out quickly. In the meantime, however, more rain fell and in consequence more swollen rivulets and *kbors* had to be crossed. On the 19th, we had to abandon the army vehicle and pushed ahead with the UNIMOG and the tractor. In spite of the rainstorm, the river was only waist deep but with a fast current. Our vehicles forged through with manual help from the villagers. The rest of the journey was uneventful except that the terrain near Geissan is so hilly that in a few places there was a real danger of the vehicles turning over into the valley. We got a rousing welcome from the residents of Geissan, a community of 1500 persons, when we reached there at 8:30 p.m. on the 21st.

"The patient's rash had healed, but clinical and epidemiological examination clearly indicated that it was a case of chickenpox.

"We began our return journey on 24 September. The return trip was even slower as more rain had fallen. On 25 September, we reached a *kbors* so heavily flooded that several days' wait would be required for the waters to recede. The writer and Abdul Gadir decided to complete the trip by boat. We obtained a small leaky fishing canoe and paddled down the flooded Blue Nile endeavoring to avoid the larger, frequent whirlpools. After 4 hours, we pulled ashore at a village to camp for the night and there were able to get a wooden boat with motor which took us to Damazien. On the following day, 27 September, 14 days after arrival, we took the once-weekly air flight back to Khartoum."

During most years and in most age groups cases were more frequent in males than in females. For adults, this was to be expected because the migrants were more often males. For younger age groups, there is no ready explanation for the sex differential. However, the data must be interpreted with caution because outbreaks were not thoroughly investigated until 1972 and, even then, investigation in the tropical forest areas was by no means complete and, in some areas, cases remained undetected because they were hidden from the investigators.

CONCLUSION

The smallpox eradication programmes in the Sudan and Zaire, two of Africa's largest countries, present a study in contrasts. When the programme began in Zaire, smallpox was highly endemic. The population was poorly vaccinated, and its professional staff and health infrastructure were at an early phase of development. Conversely, the Sudan in 1967 was free of smallpox, vaccinal immunity in the central and northern provinces was high and the country's health structure was comparatively advanced.

Both countries endeavoured to execute nation-wide vaccination campaigns employing both BCG and smallpox vaccines, the first programmes to administer the two antigens simultaneously. It was expected that there might be operational difficulties in conducting a time-limited mass campaign which required field activities to accommodate the administration of smallpox vaccine to the entire population and the administration of BCG vaccine to children and adolescents. WHO smallpox staff argued that it would be preferable to begin field operations using only one antigen, and to add the second after the programme had become established. Those responsible for tuberculosis control were anxious that BCG vaccination should be incorporated in the programme from the outset, arguing that to administer two vaccines entailed little more in cost or effort than to administer one. This view prevailed.

As was foreseen, both programmes did experience substantial problems in administering the two antigens simultaneously. Zaire, however, was soon able to resolve the difficulties by using jet injectors for both vaccines and to administer them to groups assembled at collecting points. In little more than 3 years, a

country-wide programme had been completed with a staff which, at its maximum, numbered 234 persons. In the Sudan, the assembling of the general population at collecting points was not well accepted, thus precluding the effective use of jet injectors. Smallpox vaccination was therefore conducted from house to house with the bifurcated needle, while BCG vaccine was administered by needle and syringe to children at collecting points—a system that never worked well. Despite a staff of more than 500 persons, the programme proceeded slowly and, in fact, was terminated before vaccination had been completed throughout the country.

Acceptance and understanding of the concept of a national programme for the surveillance and containment of outbreaks likewise differed in the two countries. In the Sudan, as was the practice in other countries with a comparatively well developed infrastructure of health services, provincial and district health officers had primary responsibility for disease control. These medical officers differed greatly in their abilities, their understanding of epidemiology and their perception of priorities and, with no national surveillance unit to provide support and guidance, most controlled such smallpox outbreaks as were discovered in the traditional manner—by mass vaccination. Efforts to improve reporting and to investigate outbreaks to ascertain the sources of infection were uncommon. The belief that no special national surveillance programme was required was reinforced by the fact that the Sudan had succeeded in interrupting smallpox transmission in 1963. In the absence of a national surveillance programme, the disease, following its reintroduction in 1970, spread to almost all parts of the country. When a surveillance programme commenced in 1972, transmission was stopped within 12 months.

By contrast, in Zaire, in which the health structure was less sophisticated and not so well established, the concept of a national surveillance programme was more readily accepted. This proved to be the experience in many of the less well developed countries. Although the establishment of an effective surveillance programme was greatly delayed, owing to the lack of experienced personnel, the programme in Zaire succeeded in interrupting transmission some 18 months before that in the Sudan.

The contributions of WHO and other international agencies were critical to the success of both programmes, but in neither country were they as effective as they might have been. In Zaire, transmission might have been interrupted far sooner had the promised WHO resources been provided in a timely manner; in the Sudan, the assignment of

effective advisers might well have helped to prevent the re-establishment of smallpox.

Whatever the problems, the attainment of eradication was a notable achievement in both countries, given their size, the formidable difficulties of transport and communication and the persistence of civil disorder.