SMALLPOX ERADICATION

THE GLOBAL STRATEGY

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History, myth and religion bear witness to man's age-old struggle against smallpox. Soldiers, pilgrims, primitive tribes, whole populations of large cities, royal families—all were attacked by this terrifying and disfiguring disease for which there was, and still is, no cure. Until the discovery of vaccination, the smallpox virus knew no frontiers, and no amount of potions, incantations or magic amulets could stop its relentless spread. Eventually, smallpox became endemic throughout the world.

By the nineteen-fifties, however, it had been eliminated from Europe and North America through vaccination, and had been brought under effective control in a number of countries in South America, North Africa and Asia. Yet smallpox was still a major threat, not only to countries where it was endemic but also to those freed from it; its reintroduction was an ever-present possibility. It was truly a world problem, requiring a multinational approach.

In 1958, WHO, then in existence for 10 years, called for a global eradication programme against smallpox. During the years that followed, several countries began systematic vaccination programmes aimed at eradicating the disease, but only a few were successful. It soon became evident that technical and material assistance to member countries needed to be stepped up, and programmes streamlined regionally as well as on a world-wide basis. WHO's nineteenth yearly Assembly in 1966 therefore adopted a resolution proposing intensification of the eradication programme. The new strategy came into effect at the beginning of 1967.

In that year, smallpox was considered to be endemic in 30 countries—in Africa, most countries south of the Sahara; in Asia, Afghanistan, India, Indonesia, Nepal, and Pakistan; in South America, only Brazil. Twelve additional countries reported cases believed to have been imported. Smallpox transmission had already been successfully interrupted in many developing countries in Asia and the Americas where health services were limited and communications difficult. This was an indication that the objective of global eradication was both technically and operationally feasible.

A vital need for the success of the programme was adequate supplies of high-quality freeze-dried vaccine. Surveys showed that not more than 10 to 15 per cent of the freeze-dried smallpox vaccine in use in the endemic countries in 1967 met standards recommended by WHO. The Organization assisted vaccine-producing countries by providing equipment, fellowships to train their workers abroad, and consultants to advise them on improving quality and raising output. A detailed manual on vaccine production was prepared and two WHO Reference Centres for Smallpox Vaccine were designated, one in Utrecht, Netherlands, and the other in Toronto, Canada. The responsibilities of these Centres included the testing of vaccines from other laboratories, the training of national laboratory workers in vaccine production, and the evaluation of new techniques of vaccine production.

Both the quality and the quantity of vaccines steadily improved. Several of the originally endemic countries—including Brazil, Bangladesh, Guinea, Indonesia and Kenya—began to produce sufficient vaccine of acceptable quality for their own needs. Other laboratories in Asia and South America did the same. But in addition to indigenously produced vaccine, a further 150 million doses were required annually to carry out the programme; these were donated by 20 Member States, the largest contributors being the USSR and the USA. By 1969, more than 95 per cent of all vaccine in use in the endemic countries was freeze-dried vaccine conforming to the requirements laid down by WHO.

A second consideration in the development of the programme was the technique of vaccination. Previously, most vaccinations had been administered by the easily performed scratch technique. Under field conditions, this method was found less effective than the more difficult multiple-pressure technique. Alternative techniques were sought. Newly developed jet injectors were introduced into programmes in Africa and South America, where teams vaccinated large numbers of people collecting at particular points. The proportion of successful vaccinations was as satisfactory as that obtained with the multiple-pressure method and less vaccine was required to obtain an adequate response. However, problems were encountered in maintaining and repairing the injectors and they were found to be unsuitable for house-to-house vaccination programmes in Asia.

The introduction of the bifurcated or forked needle around this time came as a great boon. WHO began to experiment with the bifurcated needle in 1967—it soon proved to be as revolutionary a device as...
Samples of vaccine from different countries (right) and vaccine production in Bangladesh. Adequate supplies of high-quality freeze-dried vaccine, easily preserved in tropical areas, are vital to success in eradicating smallpox. Today, nearly all vaccine conforms to WHO requirements. Much of it is produced in the endemic countries themselves. The balance is provided by twenty other nations, the main donor being the USSR. (Photos WHO/J. Mohr)
Vaccination techniques have been refined considerably during the last five years. Previously, vaccine was administered by the scratch technique with a variety of vaccinostyles (right). The jet injector (below), introduced for routine field use in 1967, was more rapid and effective but presented maintenance problems. Most recent is the bifurcated needle (left), first employed in 1968. The needle is simply dipped into vaccine and the skin pricked rapidly about 15 times. The bifurcated needle has proved to be as revolutionary a device as the safety-pin in its time. With it, a single vaccinator can perform as many as 1500 vaccinations a day. (Photos WHO)
the safety-pin in its day. With the needle, the rate of successful vaccination was found to be superior to that obtained by other devices, and the amount of vaccine required was reduced to one fifth. A vaccinator could learn to work with it in an hour or less. The needles could be sterilized easily and repeatedly, and there was no question of breakage or maintenance. Teams using the needle in Rwanda were able to do 1,000 to 1,500 vaccinations per day per vaccinator. Once the vaccination technique had been simplified, the programme went into full swing.

While these problems of vaccine and vaccination were being resolved, WHO co-operated with health authorities to plan smallpox eradication programmes in each of the endemic countries and in many countries particularly vulnerable to the introduction of smallpox owing to their geographical situation. Some programmes began in 1967, but most started in 1968 and 1969. The last of the endemic countries to begin was Ethiopia, in 1971. In all, WHO assisted programmes in more than 50 countries.

The strategy and operational techniques have been adapted in national programmes to existing health structures and patterns of vaccination activities. Every programme has two principal components: 1) surveillance, including disease notification and field investigation and containment of outbreaks; and 2) systematic vaccination, including assessment of the results achieved. In the past, eradication programmes consisted almost solely of mass vaccination; with the present strategy, surveillance is the keystone. There are several reasons for this.

The objective of the programme is a zero incidence of smallpox—no cases at all, anywhere. When the characteristics of people who contract the disease are known, vaccination programmes can be aimed at high-risk groups. Analysis of surveillance data indicates that in most countries more than 85 per cent of cases occur among those who have never been vaccinated, and more than 80 per cent among children less than 15 years old. In many areas a disproportionate number of cases occur in lower socio-economic groups in the cities, and frequently it is individuals belonging to these groups who introduce the disease into rural areas. Accordingly, vaccination programmes now place more stress on primary vaccination of children and on the vaccination of poorer city-dwellers.

In addition to being a highly useful device to define high-risk groups, surveillance plays an even more important role in interrupting the transmission of smallpox. In some areas, despite a high rate of vaccination coverage, smallpox transmission persists at low levels, the disease continuing to spread from one person to another among a very small number of susceptible individuals. Active measures to identify and contain outbreaks, however, have sometimes caused transmission to be interrupted even where less than half the population had been vaccinated. The remarkable efficacy of surveillance and containment measures can be explained by the epidemiological behaviour of smallpox, elucidated through the surveillance programme and in special studies.

Smallpox is an unusual disease, as its presence in an area can be readily detected. Each person infected with the virus develops the characteristic rash and can transmit infection until his scabs disappear. There are no silent or subclinical infections and the virus is not present in animals or insects. If the virus is to persist in an area, the infected person must transmit the virus to a second person and he to a third person in a continuous chain. If the infected person does not transmit the virus to anyone, the chain is broken and the outbreak stops. In remote villages and nomadic population groups, this may occur even though no specific measures are taken. Furthermore, if the source of infection of the first case in a village can be determined, previously unrecognized or unreported foci can be detected and similarly contained.

The key role in all smallpox eradication programmes is therefore played by two or three national or provincial surveillance teams, headed by a physician or health inspector. The teams consist of two to four people who travel constantly. They feed the reporting system, search for cases, investigate reports of any outbreaks and take measures to contain them. One team can normally do all that needs to be done in a population of two to ten million people. Experience has shown that all outbreaks can be investigated and contained by one to five teams based centrally or—in the case of large countries—at provincial or state headquarters.

As a supporting measure, systematic vaccination is being carried out in virtually all countries. By increasing the proportion of immune people, vaccination creates a partial barrier to transmission and reduces the number of chains of transmission that require the attention of surveillance teams. Whether vaccination is performed by special teams or individual vaccinators, efforts are always made to obtain the maximum participation of the existing health services. Where programmes are
Conducted by teams, an assessment unit evaluates the coverage and rate of successful vaccination in a sample of the population one to two weeks later. If 80 per cent or more of all age groups, particularly the 0-4-year-olds, show a vaccination scar, and if at least 95 per cent of primary vaccinations are successful, the performance of the vaccination team is considered satisfactory.

Since 1967, both the incidence of smallpox and the number of countries reporting cases have decreased significantly. In 1967, the number of cases reported was 131,418. Surveys conducted since 1967 suggest that less than 5 per cent of all cases were then being reported; the actual number of cases is thus estimated to have been at least 2.5 million. Despite increasingly complete reporting, smallpox incidence declined each year until 1970, when 33,318 cases—the fewest on record—were reported. In 1971, however, the reported incidence rose to more than 52,000 cases. Half of these were accounted for by Ethiopia which, beginning in 1971, developed a highly effective eradication programme (see page 22). In the rest of the world, smallpox incidence decreased by more than 25 per cent for the fourth consecutive year. With all endemic countries engaged in eradication programmes, at least one third of all cases are now believed to be notified. The actual number of cases in 1971 is thus estimated to be less than 200,000, in contrast to the 2.5 million cases estimated for 1967.
smallpox decreased from 42 in 1967 to 16 in 1971. Of the 42 countries reporting smallpox in the former year, 30 were considered to be endemic, whereas the remaining 12 notified imported cases. At present, continuing transmission is believed to be limited to 7 countries: Bangladesh, Botswana, Ethiopia, India, Nepal, Pakistan and Sudan. In addition, 9 other countries have reported indigenous cases within the past two years. Since these cases were not known to have been imported, the interruption of transmission in these countries must still be regarded as provisional.

With the decrease in smallpox incidence, importation of the disease into Europe has become less frequent. During the first two years of the programme, 1967 and 1968, smallpox was imported into Europe on six different occasions but in the four years subsequently, only three times—twice in 1970 and once in 1972. The last introduction occurred in April 1972, when a Yugoslav pilgrim, infected in Iraq, brought the disease back to his own country (see page 28). No cases have been imported into North America since 1962.

In 1967, the smallpox endemic countries were considered to fall within four regions: South America, Indonesia, Africa and the mainland of Asia. It was considered unlikely that smallpox would be transmitted between any two of these regions. And, indeed, during the last five years, no such transmission has been detected. Thus, when smallpox transmiss-
ion is interrupted in one of the regions, it will probably remain free from smallpox. Two of the four regions, South America and Indonesia, now appear to be smallpox-free.

In South America, more or less extensive smallpox eradication programmes have been conducted in various countries during the past 20 years. By 1967, endemic smallpox was being reported only in Brazil, which began an eradication programme in that year. During the next four years, 83.3 million out of a population estimated in 1971 at 94 million people were vaccinated in a well organized and carefully assessed programme. Surveillance activities were begun in July 1969 and the smallpox incidence subsequently fell precipitously as the detection and notification of cases improved. During 1970, a steady decline in incidence occurred until mid-November, when zero incidence was first recorded. Subsequently, a single localized outbreak of 20 cases was detected in suburban Rio de Janeiro and lasted until April 1971, when the last known case of smallpox in South America was reported. Surveillance units were established in each of the states of Brazil and more than 3,800 reporting posts throughout the country are continuing their activities.

Several other countries in South America have intensified their vaccination programmes in the past five years. Cases were imported into three countries during this period and in each instance Brazil was shown to be the source of infection. Since the last case was reported from Brazil, an intensive search for possible residual endemic foci has been undertaken and initially successful. Transmission appears to have been interrupted. Intensive surveillance, however, will be needed for at least two years before interruption can be definitely confirmed.

In Indonesia, the second of the target areas, an eradication programme began in July 1968 in Java and Bali, and was subsequently extended to include the outer islands. Surveillance and containment measures were primarily emphasized although routine vaccination was also improved. During the first three years of the programme, between 10,000 and 18,000 cases were notified annually but, in 1971, the number decreased sharply to 2,000. In 1972, only 34 cases were reported, all of which occurred in west Java during January. A national search for cases was conducted over the succeeding months and special surveillance teams are continuing this activity. No cases, however, have been detected. The results are encouraging but, as in South America, it is too early yet to be absolutely certain that transmission has been stopped.

In 1967, smallpox was widely endemic throughout most countries of Africa south of the Sahara. During the past five years, eradication programmes have been undertaken by most of the African countries. Except in Botswana, Ethiopia and Sudan, reported smallpox incidence has now decreased to zero.

In 20 countries of western and central Africa, with a total population of 120 million, reported smallpox incidence declined to zero in October 1969. One additional outbreak was detected in Nigeria in March 1970, the last known case occurring in May 1970. Surveillance and vaccination programmes are continuing throughout this sub-region.

In the countries of eastern and southern Africa, outside of Ethiopia and Sudan, smallpox incidence declined steadily during the course of the programme, apparently reaching zero incidence following the occurrence of two cases in Zaire in September 1971. Subsequently, it was discovered that Botswana, previously smallpox-free, became infected almost at the time the last cases were occurring in South Africa. There were 1,000 cases before the epidemics could be controlled. Introductions of smallpox from Ethiopia and Sudan also occurred into the French Territory of the Afars and Issas, as well as into Uganda, but were successfully contained.

The two countries of main concern in Africa are Ethiopia and Sudan. In Ethiopia, the programme started in January 1971 is based on a strategy consisting chiefly in surveillance, vaccination in conjunction with containment activities, and systematic vaccination in the largest towns and along the main roads. During 1971, over 25,000 cases were detected, compared with only 722 in 1970. Over six million people have been vaccinated to date in a population in which few had previously been vaccinated. Since March 1972, the number of reported cases has decreased, and programme officials now believe that transmission in 9 of the 14 provinces can be interrupted by the end of the year.

In Sudan, more than 1,000 cases were reported both in 1970 and 1971—the highest incidence recorded in 15 years. A somewhat larger number of cases is expected to be recorded in 1972. Present information suggests that Sudan succeeded in interrupting transmission in the early 1960's. The disease appears to have been reintroduced in 1968 and, in the absence
ENDEMIC COUNTRIES 1967

ENDEMIC COUNTRIES AND IMPORTATIONS 1972

Imported cases
of effective surveillance, spread throughout the country during the next two years. Since 1968, a partially effective eradication programme has been in progress in the northern and central provinces, but activities have only begun in the three southern provinces, from which more than three-quarters of all cases are now being reported.

As more intensive efforts are being applied in Ethiopia and Sudan, other African countries are remaining alert to prevent possible importations. Vaccination programmes are continuing in order to maintain a high level of vaccination immunity.

Since 1967, the only known endemic countries on the mainland of Asia have been Afghanistan, Bangladesh, India, Nepal and Pakistan. China is reported to have become smallpox-free after intensive vaccination campaigns in the 1950's. Burma, Iraq, Iran, Syria and countries of the Arabian peninsula have recorded only infrequent importations of smallpox from the endemic countries in Asia.

In the fourth year of a well-executed programme, Afghanistan experienced a considerable decrease in incidence during 1972 and since February all cases have been among immigrants from Pakistan and their contacts. The first round of a systematic vaccination programme was completed early in 1972 and a second round has begun to assure that high levels of vaccination immunity are maintained. Special surveillance teams are continuing to move systematically through the country searching for cases.

Most cases reported by India during 1971 and 1972 occurred in its northern states. With improving surveillance activities and better notification, the number of reported cases increased from 12,000 in 1970 to 16,000 in 1971. The total in 1972 is expected to approach the 25,000 mark. After 10 years of intensive vaccination programmes throughout the country, immunity everywhere is comparatively high. However, smallpox has continued to spread, primarily among unvaccinated people, who are estimated to constitute no more than 10 per cent of the population. Efforts are now being made to improve the reporting system as well as the efficacy of surveillance and containment activities in order to interrupt the chains of infection. Much, however, still remains to be done.

Bangladesh, which became free of smallpox in August 1970, experienced a recrudescence at the time of return of infected refugees from India early in 1972. Major outbreaks occurred in 5 of the 19 Districts and, despite emergency measures, it has not yet been possible to control them.

Pakistan began an eradication programme in 1968 in its largest province and subsequently extended it to the remaining three provinces in 1971. As in India, vaccination immunity is comparatively high and, with the development of an effective surveillance programme, transmission should soon be interrupted.

Nepal has been conducting a steadily expanding and effective programme over the past four years. Most outbreaks during the past year have occurred near the Indian border and have been shown, or are suspected, to have originated from imports from India. The problems of smallpox eradication in Nepal are inseparably linked with those of neighbouring India, whose principally afflicted areas are on or near the Nepalese border.

The amazing reduction in smallpox cases in only five years—from 2.5 million to 200,000—is due to the dedication and perseverance of national and WHO staff alike, working in the field under difficult conditions. Their efforts have been indirectly recognized by the governments of the United States and the United Kingdom, who have made smallpox vaccination no longer a routine procedure. They believe that the risk of importation is now slight, and that an eventual outbreak could easily be contained. In the two countries, vaccination is now reserved for people travelling to endemic areas and for health service staff in contact with patients. It is too soon for all other governments to do the same, since not all countries are so far from endemic areas nor do all have such advanced health services. But if special efforts in the WHO smallpox eradication campaign are made during the next two years, smallpox incidence throughout the world could reach zero or near-zero levels. With a final effort and the mobilization of resources, mankind’s most feared killer, as well as smallpox vaccination itself, could be relegated to history.