

Smallpox throughout the world is reviewed. Since 1944 great progress has been made and the number of endemic countries reduced from 62 to 37. Factors which have hitherto prevented faster progress are considered, and the role of national and international agencies in hastening final eradication is discussed.

PROGRESS IN INTERNATIONAL SMALLPOX ERADICATION

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TWENTY years ago—in 1944—over 400,000 cases of smallpox were reported. By 1947 the number had dropped to under 100,000 but in 1951 rose again to over half a million as a result of an extensive epidemic. Apart from this, and a smaller one in 1958, the incidence has been generally downward and in 1965 reached the relatively low level of 50,000 cases. These are the reported cases. The relation the figures bear to the real incidence of the disease is unknown but are certainly an underestimate. The real incidence is in fact very much higher.

Notification of most infectious diseases is to some extent deficient in every country no matter how good the coverage provided by the medical services may be. But for at least some diseases in many countries we know that it is safe to assume that the pattern as reported bears a reasonably constant relationship to the true pattern of the incidence or mortality, though often running at a lower level. There is no assurance, however, that analysis of the reported cases of smallpox provides information of any predictable degree of accuracy. In many of the endemic countries the political and social changes of the past two decades have influenced the reporting of disease. In some, notification is now more complete but in many, especially in Africa, it is far less

complete than before. Too much weight should not be placed on the reported reduction in incidence taken by itself, but a comparison of the geographical distribution of the disease over the past 20 years lends support to the evidence from the notifications.

For the purpose of this comparison I have arbitrarily defined an endemic country as one reporting an annual average of 50 or more cases in any three years around 1944 and 1964. This definition has been applied to countries in which figures of reported cases are available. In 1944, of the countries which made reports there were 32 endemic in Africa, 11 in America, 16 in Asia and 3 in Europe.

Twenty years later (1964) there was little change in Africa except north of the Sahara where five countries had become smallpox-free. In the other three continents very substantial changes occurred. In America only three countries are now endemic—Brazil, Colombia, and Peru. (Peru has once more become endemic after a period of freedom from the disease as the result of an intensive campaign in the early 1950's which was unfortunately not sustained in later years.)

In Asia only three of the originally mentioned 16 countries are endemic—Burma, India and Pakistan—but to these must be added Afghanistan, Ne-

pal, and the Yemen, which were not reporting in 1944, and Indonesia which was then free but is now highly endemic. In Asia, therefore, there are now seven endemic countries instead of 16. In Europe none of the countries now has endemic smallpox.

Most of the world's smallpox occurs in Asia—66 per cent of the total occurred there in 1965 and 72 per cent in 1964. Most of the remainder occurs in Africa. In Asia the principal contributor is India. In 1965 India contributed 83 per cent of the cases in Asia and 55 per cent of the world's total.

Though the absolute number of cases is greatest in Asia the incidence per head of population is greatest in Africa. Africa south of the Sahara is thoroughly seeded with smallpox and must always be considered a potential danger to itself and the rest of the world.

A vaccine giving good immunity has been available since the last years of the 18th century and it seems at first sight remarkable that the highly fatal and disfiguring disease has not yet been eliminated from the world.

The reasons for past failures are not all known. Some of them are mentioned below, not necessarily in order of importance.

1. Acceptability of the Vaccine

Smallpox vaccine gives a high degree of immunity but the reactions render it unacceptable to some people even in endemic countries, and the complications which occasionally follow its use cause anxiety in countries where the incidence of smallpox is low or where the disease is usually absent.

2. Potency at the Time of Insertion

Adequate precautions are not always taken to ensure that the vaccine is fully potent at the moment of insertion into the vaccination site. The instability of the vaccine in the presence of warmth and light is often forgotten by medical

men themselves and vaccinators in tropical countries working often far distant from their medical supervisors will sometimes be even less mindful of the need for the strictest care in handling their vaccine.

3. Potency of Vaccines for Primary Vaccination and Revaccination

For many years it was believed that a vaccine which gave a high proportion of successful primary vaccinations was satisfactory also for revaccinations. It has only recently been clearly demonstrated that vaccines of relatively low potency will be effective in primary vaccination but will fail to give takes in more than a small proportion of revaccinations. In India, for example, it was found that the revaccination take rate could be raised from less than 15 per cent to over 50 per cent by using a more potent vaccine. The continued high endemicity of smallpox in India despite the routine vaccination programs over the past century may be due in considerable part to the low potency of the vaccines used for revaccinations.

4. Priorities in Health Programs

The control or elimination of smallpox does not always receive the highest priority in the endemic countries. This is true in Asia and to a greater extent in Africa. In Africa the classical severe smallpox commonly occurs but variola minor is also common and there is some evidence (which attempts are being made to confirm) that a variety of smallpox intermediate between variola major and variola minor may also exist. The variable severity of the disease is of scientific interest but it has also a practical bearing on the allocation of the invariably limited funds available for health services. We can have sympathy for the administrator or politician who finds it difficult to determine the degree of emphasis to be put on smallpox control. In the developing

countries it is estimated that there are 10 to 20 million cases of active tuberculosis, that two to three million new cases occur every year and that one to two million die annually. To the problems of tuberculosis add the problems of malaria, malnutrition, parasitic diseases, and the pneumonias and some idea is obtained of the magnitude of the task of health improvement in these countries.

5. Absence of Adequate Health Services

The most important reason of all for the current presence of smallpox in the world is the paucity of the health services in nearly all the endemic countries and their virtual absence in large parts of some of them.

There are, therefore, many reasons for the failure to eliminate smallpox from the world. Those who think that the endemic countries should have rid themselves of the disease long ago should remember that the countries now free from smallpox have reached that state only recently. Smallpox was still endemic in the United States of America 20 years ago. The United Kingdom was not freed from the disease until some time between the two world wars—this despite compulsory vaccination for many years.

Global Eradication of Smallpox

In 1958 the delegation of the USSR to the 11th World Health Assembly proposed that a program of global smallpox eradication should be sponsored by the World Health Organization, and said that eradication would not be particularly difficult even in countries without highly developed public health services.

In the USSR 90 million people were vaccinated in two years (1934-1935) and shortly afterwards the disease was eradicated. The delegation thought that if a start were made in 1958, global eradication could be achieved by the

end of 1962. In the discussion there was enthusiasm for the idea, though those with experience of the persistence of smallpox in the tropics thought that the estimation of success in four years was much too optimistic. At the 12th World Health Assembly in 1959 the role of individual countries and of WHO was defined. The Assembly resolved that WHO should: "(1) . . . urge health administrations of those countries where the disease is still present to develop eradication programs and to offer them any necessary technical guidance and advice; (2) provide for the necessary activities to further smallpox eradication programs and for the assistance requested by national health administrations for this purpose in its program and budget for future years; and (3) collect information on the organization and progress of their respective eradication programs."

It is important to note that the primary responsibility for the development of eradication programs in the endemic countries was put upon the countries themselves. The function of WHO has been to give technical and administrative guidance; to arrange for the training of laboratory personnel; to arrange training courses for clinicians and epidemiologists; to try to obtain from outside sources—mainly the governments of nonendemic countries—the equipment, vaccine, and other essentials which cannot be found locally; and to collect annually information on progress.

Implementation of the WHO Resolution

Information on the implementation of the resolution during the past seven years is given below:

Donation of Vaccine

WHO has, from the start, insisted that only heat-stable vaccine conforming to the potency requirements established by its Expert Committee on Bio-

logical Standardization should be used in the campaign and all the smallpox vaccines offered to the organization are tested for potency before they are accepted.

It is an indication of the wisdom of this decision that of 12 vaccines recently offered (representing about 10 million doses) seven have not met the potency, stability, and sterility requirements.

So far, a total of about 50 million doses of vaccine have been donated to the organization for distribution in the campaign. Twenty-five million of these were donated by the USSR and the remainder by 10 or 12 other countries.

In addition the USSR has given about 450 million doses to India and other countries in Southeast Asia by bilateral arrangements. Without these donations from the USSR, WHO could have done little to meet the immediate vaccine requirements of the national eradication programs.

Local Production of Vaccine

The supplies of vaccine from outside sources are required for the mass vaccination campaigns. For the subsequent routine control programs which will have to be continued after the main attack has been completed, the policy is to assist countries to produce their own vaccine.

Thanks to WHO/PAHO assistance, local vaccine production in Latin America is now adequate.

In conjunction with UNICEF, WHO has gone far to meet the need in Asia. In India and Burma personnel have been trained, freeze-drying equipment has been supplied, consultants have visited the local laboratories to assist in the early stages of production, and the first lots have been carefully checked for potency and stability. Indonesia and Thailand have established their own production laboratories. Pakistan already produces as much vaccine as it

requires, both for mass immunization and for regular use.

Because there are so many countries in Africa, some with small populations, it would be wasteful for each to produce its own vaccines. The establishment of two regional smallpox vaccine centers is being considered—one in East Africa and one in West Africa. Staff for the laboratory in East Africa are recipients of WHO fellowships and are now being trained in European laboratories. The necessary equipment has been ordered. In West Africa progress is a little slower but prospects are good.

Technical Guidance

In addition to its very effective efforts to get vaccine produced in the endemic countries, the organization has carried out an extensive advisory program on other aspects of the campaign. It has prepared for the guidance of countries which are planning eradication programs a document giving detailed information on the steps necessary for the organization of an effective campaign. This was recently revised in accordance with the recommendations of an Expert Committee on Smallpox which met in 1964. The revised document also embodies the experience gained in recent years. It advises that the aim should be to vaccinate 100 per cent of the population within three years. The figure of 100 per cent is given because it has been found that if the figure of 80 per cent is adopted this can be reached without having necessarily covered more than a moderate percentage of some population groups in whom infection may still spread, e.g., babies under one year of age; men working in the fields all day; nomads, etc. It stresses that stable freeze-dried vaccines are essential and that after reconstitution they must be used with the same care as is necessary in the tropics for liquid vaccines. It

points out that for a successful campaign it is essential to have an efficient campaign administration which has ready access to the chief of the health services and an effective regional and peripheral structure. In planning campaigns three phases are recommended—preparatory, attack, and maintenance, and the document gives guidance on the action necessary in each phase. A strong plea is made for national teams to carry out independent evaluation of the work of the vaccination teams. The value of this concurrent but independent evaluation has been clearly proved in the Indian National Eradication Campaign.

The organization has provided consultants to advise on the campaigns and in some countries medical officers or sanitarians have been appointed to work with the local staff. Two smallpox conferences, arranged by WHO headquarters, were held to give senior officers concerned with smallpox in health administrations an opportunity to meet and examine problems, exchange experiences, and coordinate the activities of contiguous countries. One was held in Africa and 22 countries were represented. The other was held in India and 15 countries were represented. In addition seminars on production of freeze-dried vaccine and on clinical and epidemiological questions have been held.

Research

A program of research on technical problems allied to the eradication campaign has been sponsored and has dealt with such questions as the importance of highly potent vaccines for revaccination: the use of gamma globulin and chemoprophylaxis; the spread of virus from patients into the environment; and the development of inactivated vaccine.

Achievements

In the seven years of the program nine countries endemic in 1958 have

reached the stage when cases are no longer occurring regularly; three others are almost at this stage. Eleven countries are in the midst of eradication campaigns. They include all the endemic countries of Latin America and all but two of the countries in Asia.

Some countries have put great efforts into their campaigns. For example, in India 420 million vaccinations have been made and it is hoped to complete the first round of vaccination of the total population before the middle of 1966. This has been achieved with 150 field teams each containing one medical officer, and 87 other members including two health educators—a total of about 14,000 persons (including headquarters and regional staff). In East Pakistan, 15 to 20 million vaccinations have been made annually in recent years. Other countries have been equally active but India and Pakistan are mentioned because elimination of smallpox in these two countries would of itself completely change the outlook on smallpox as a world problem.

Problems

Not all the programs are, however, as effective as they might be. The situation in Africa is much less satisfactory than in America and Asia. Few countries in Africa have set up eradication programs and those which have done so are not yet reporting much progress.

Because of anxiety about the rate of progress in the campaign as a whole, the organization recently sent a team of two consultants and a member of the secretariat to four representative endemic countries, two in Asia and two in Africa, to assess the present position and to advise on means of improvement. The problems they found were many.

One, already discussed, is the question of the degree of priority given to smallpox eradication by national governments.

Another which the team found striking in all four countries visited is the

lack of adequate national administrative and supervisory structure at the central, regional, and local level for the execution of the program.

Lack of assurance of an adequate supply of vaccine is another constant hindrance to forward planning and efficient use of manpower. All the countries lacked transport and refrigeration equipment.

The team found that not nearly enough attention has been paid to health education and to past beliefs and prejudices of local populations.

They found also that not enough effort has been put into ensuring that contiguous countries run simultaneous campaigns. This is specially important in Africa where large numbers of people are constantly moving across national boundaries.

Conclusions

To sum up the present situation, it would be fair to say that in Latin America the prospects for rapid eradication of the disease are very good.

In Burma, India, and Pakistan the prospects are also good provided the present efforts are sustained. In Afghanistan, Nepal, Yemen, and Indonesia there are considerable problems to be overcome but, given a strong spurt, eradication from these countries need not be long delayed.

Africa poses the greatest problems. Before a realistic program can be prepared it will be necessary to study possible approaches carefully, to decide just how much can reasonably be expected from local resources and how much will have to be supplied from outside, and to find out how problems of coordination of national campaigns can be over-

come before a realistic timetable can be prepared. WHO has appointed two regional smallpox medical officers to study the needs—one for East Africa and one for West Africa. They are at present visiting individual countries and are assessing the needs by personal observations.

At the same time the organization is making a detailed reappraisal of the whole position and is preparing a revised and intensified program.

The smallpox-free countries are spending great sums on keeping themselves free. The estimate of the cost for the United States of America is \$15,000,000 annually, for Sweden \$850,000 and for Czechoslovakia \$1,000,000. For all the smallpox-free countries together the sum must run into hundreds of millions of dollars. Probably for somewhere in the region of \$50 million (or at most \$100 million) of international aid, a successful program could be mounted.

Without special effort social and medical progress would in time ensure the disappearance of smallpox from all but the most remote areas of the world. But given funds and a strong determination in the endemic and nonendemic countries to join together and take immediate steps to vaccinate adequately the populations at risk and to maintain a high level of immunity for some years, the process of eradication could be greatly accelerated and within a decade the global problems of smallpox could be overcome.

The new program which the organization presented to the 19th World Health Assembly in Geneva in May 1966, and which has now been accepted by the Assembly is designed to achieve this objective.

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This paper was presented before the Epidemiology Section of the American Public Health Association at the Ninety-Third Annual Meeting in Chicago, Ill., October 20, 1965.