

The Feasibility of Smallpox Eradication

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IN JUNE 1958 the World Health Organization gave consideration to a proposal that it undertake a worldwide smallpox eradication program. The proposal was approved in principle, and the Director General was instructed to study the feasibility and possible means of accomplishing the task.

WHO's action lends timely interest to smallpox control experiences such as a group from the Communicable Disease Center of the Public Health Service had in the spring of 1958 in East Pakistan. This Province, formerly known as East Bengal, has long been known as a stronghold of smallpox and a place where control efforts are beset with difficulties as great as any to be found in the world. If eradication of the disease is feasible in the circumstances presently existing there, it should be feasible anywhere.

The occasion for the CDC team's trip was a smallpox epidemic of alarming proportions. Many countries, including the United States, extended assistance in combating both this epidemic and a cholera epidemic that was raging concurrently. U.S. assistance was coordinated by the International Cooperation Administration's Mission in East Pakistan under the direction of Dr. Thomas A. Cockburn, ICA's public health adviser in Dacca.

This team reported to Dr. Cockburn and with him to the Minister of Health and Home Government of East Pakistan. It was assigned the task of serving as the "eyes and ears" of the smallpox control campaign with the following duties:

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1. Study the history and characteristics of smallpox epidemics in East Pakistan and the various related factors.

2. Define the nature, extent, and distribution of the smallpox epidemic.

3. Assess the resources that could be brought to bear on the control of the epidemic and the obstacles to be overcome.

4. Evaluate the current control campaigns in the districts and identify areas of success and failure.

5. Identify, in cooperation with Pakistani health personnel, epidemiological factors of importance to the smallpox control program.

In the execution of these duties the need to obtain data that would be as nearly representative as possible of the entire Province led to field trips to all 17 of its districts. Team members traveled by airplane, train, river steamer, jeep, oxcart, rickshaw, "country boat," and on foot. On most trips each of us was accompanied by a young Pakistani physician who had volunteered his assistance. The associations with these dedicated young men turned out to be most rewarding both to them and to us.

It is not the purpose of this paper to describe the control campaign that was conducted or the activities of the team. Some of our observations, however, are pertinent to the question of whether it would be feasible to attempt eradication of smallpox in East Pakistan at this time, and what would be required in order to achieve this goal.

Two Crucial Factors

The history of smallpox in Bengal and East Pakistan may be seen at a glance in figures 1 and 2. For as far back as records have been kept, the disease has occurred in cyclic waves. Figure 1 illustrates these cycles for the period 1912-46 in all of Bengal prior to the 1947 par-

tition. Figure 2 shows the smallpox deaths in East Pakistan from 1948 to 1958.

From these data may be derived the first crucial factor of the problem: smallpox is deeply entrenched in East Pakistan as an endemic and epidemic disease. Despite the fact that much vaccinating has been done (small sampling surveys performed by the team demonstrated that 60 to 90 percent of the population had been vaccinated), epidemics continue to recur in cyclic waves.

The other crucial factor of the situation is the extreme density of the population, which obviously must have great significance in maintaining the endemicity and epidemicity of the disease. With 45 million people crowded into a land area slightly smaller than the State of Illinois, the average population density is 777 persons per square mile.

“Density of Susceptibles” Concept

The significance of East Pakistan’s great population density is demonstrated by the team’s study of the manner in which the 1958 epidemic developed and peaked.

This epidemic was not a sudden occurrence. Although figure 2 shows the increased incidence for the Province as a whole starting in 1956, reports by district that were available to the team showed that the increase in Dacca started as early as 1955. From that year until 1958 there was a gradual buildup of the epidemic. Dacca and Tippera Districts are the most populous of the Province’s 17 districts, with population densities of about 1,500 persons per square mile.

The appearance of conspicuous numbers of smallpox deaths in Dacca District was followed by similar occurrences in 1956 in Tippera District and in a few of the other more populous districts. The peak of the epidemic was reached in Dacca, Tippera, and two other districts in the spring of 1957, a full year before the peak of the epidemic in the Province as a whole. Conversely, the most sparsely populated district, Chittagong Hill Tracts, remained essentially epidemic free throughout the entire period. Only a few sporadic deaths were reported in 1958.

The team made a few samplings of the vacci-

Figure 1. Deaths per 1,000 population from smallpox in Bengal, 1912–46

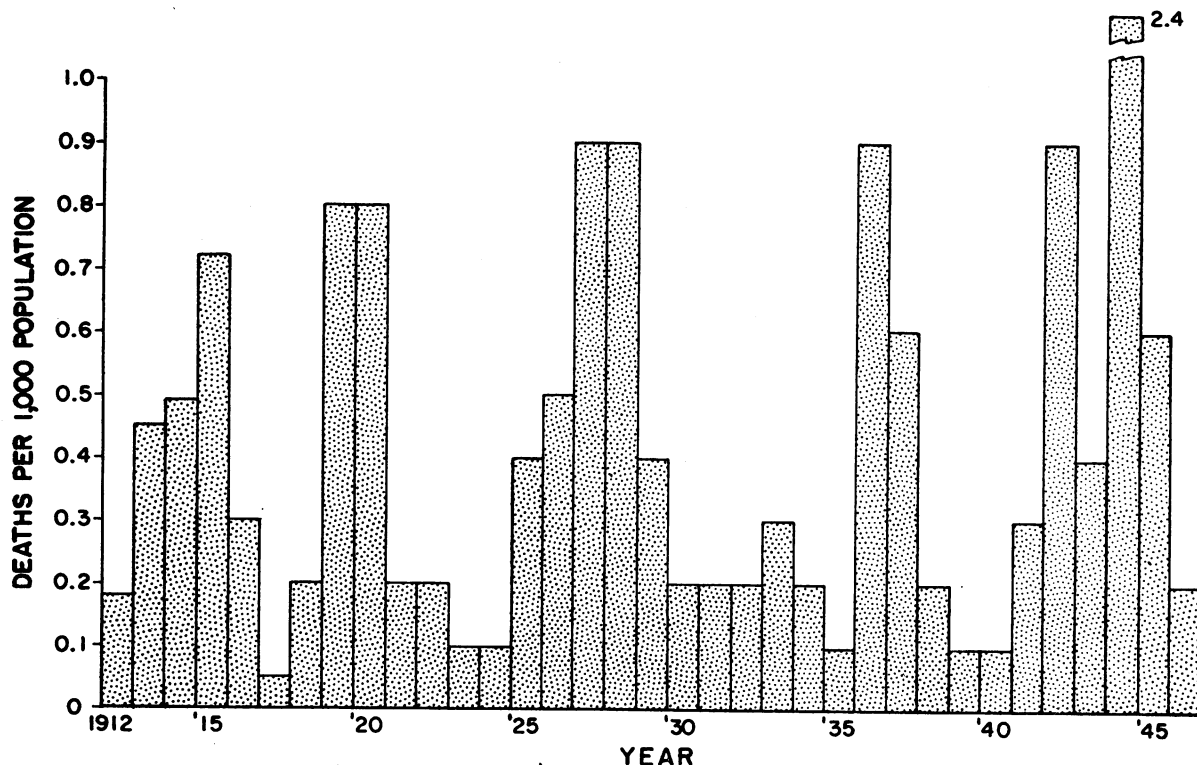
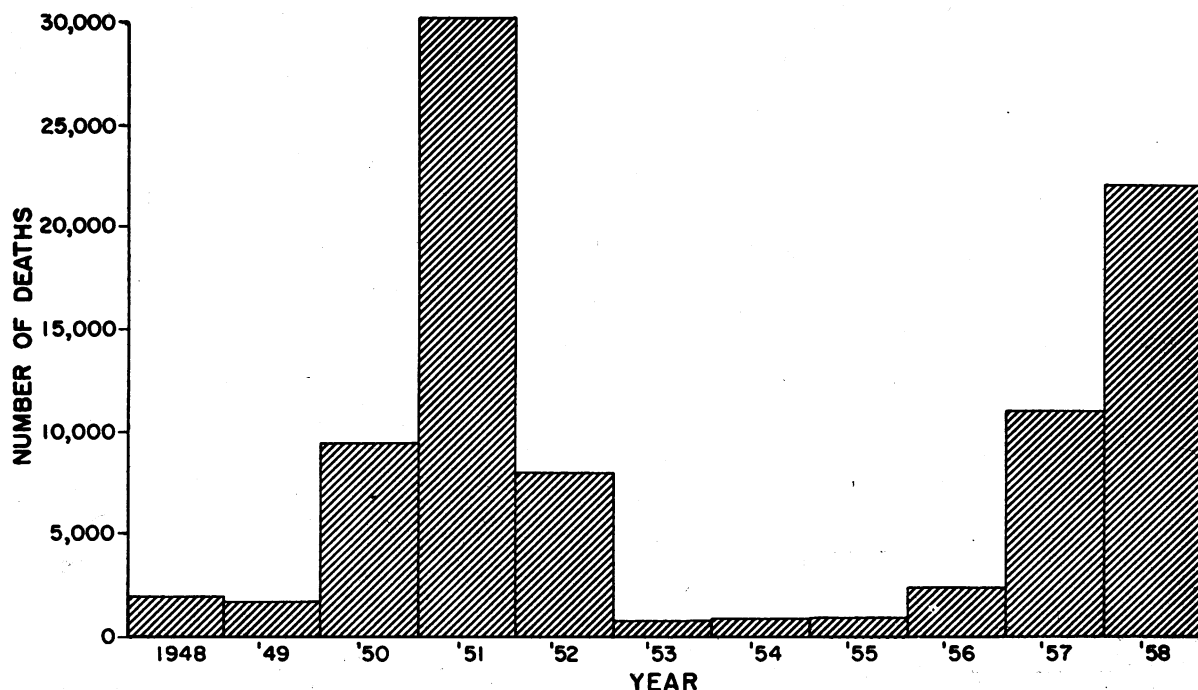


Figure 2. Deaths from smallpox in East Pakistan, 1948-58



nation status of the people in most of the districts, as evidenced by the proportion of persons having vaccination scars. On the basis of these surveys, the team made some very crude estimates (the best we could do in the available time) of the proportions of the district populations that had been vaccinated. These estimates ranged from about 60 to 90 percent (including old vaccinations), but we were unable to find any correlation between the proportion of the population that had been vaccinated and either the time of onset or the intensity of the epidemic in various districts.

As a result of the observations described in the preceding three paragraphs, it was the team's impression that, within this 60-90 percent range of proportions of persons vaccinated, both the time of epidemic onset and the intensity of the epidemic were more closely related to population density than to vaccination status. This conclusion leads to the suggestion that the density, that is, the number per square mile, of unvaccinated persons would be a better index of the susceptibility of East Pakistan's dense population to a smallpox epidemic than the index that is ordinarily used, the proportion of the population that has been vaccinated.

This, of course, is the well-known concept of the density of susceptibles. It should be useful in identifying sections of the country where vaccination campaigns need to be intensified.

Age, Sex, and Social Groups

Although the density of susceptibles is believed to be a better indicator than the proportion of vaccinated persons, it is admittedly only a crude index of the vulnerability of a population to smallpox epidemics. Obviously of great importance also is the uniformity of distribution of susceptibles among various segments of the population, such as age, sex, and social groups. If there are excessive numbers of susceptible persons in one or more of these population segments, their excessive vulnerability would be expected to result in a greater degree of vulnerability of the total population than the mean density of susceptibles would indicate.

In the East Pakistan epidemic we found that children under 10 years of age were not as well vaccinated as older age groups. This fact was reflected in the age distribution of cases and deaths (table 1). It was clear that special attention needed to be given to improving the vaccination status of children.

Table 1. Age distribution of smallpox cases and deaths in Mitford Hospital, Dacca, and in selected districts, East Pakistan, January–May 1958

| Age group (years) | Cases | | | Deaths | | | | |
|-------------------|------------------|----------------|--------|------------------|------------------|-------------------|-------------------|--------|
| | Mitford Hospital | Pabna District | Total | Mitford Hospital | Tippera District | Faridpur District | Dinajpur District | Total |
| 0-1 | 4 | 49 | 53 | 2 | 34 | 16 | 37 | 89 |
| 1-4 | 32 | 245 | 277 | 17 | 199 | 122 | 236 | 574 |
| 5-9 | 32 | 209 | 241 | 12 | 121 | 125 | 152 | 410 |
| 10-14 | 25 | 77 | 102 | 11 | 19 | 26 | 22 | 78 |
| 15-19 | 21 | 32 | 53 | 10 | 21 | 16 | 12 | 59 |
| 20-29 | 63 | 307 | 422 | 24 | 43 | 53 | 11 | 131 |
| 30-39 | 27 | | | 9 | 33 | 44 | 10 | 96 |
| 40-49 | 15 | | | 4 | 32 | 30 | 8 | 74 |
| 50-59 | 6 | | | 2 | 36 | 17 | 2 | 57 |
| 60 and over | 4 | | | 2 | 36 | 11 | 1 | 50 |
| Total | 229 | 919 | 1, 148 | 93 | 574 | 460 | 491 | 1, 618 |

Since Moslem women of Pakistan are in purdah and consequently lead a secluded life, the team expected to find substantial differences in the vaccination status and prevalence of the disease in the two sexes. This, however, did not turn out to be the case. Sampling surveys revealed approximately equal proportions of unvaccinated persons in males and females. Table 2 shows that in the areas studied, except for Mitford Hospital, the male and female cases and deaths were approximately equal. (Field observations failed to lend credence to the suspicion that the seclusion of women might result in their cases and deaths being less well reported than those of men.)

Table 2. Sex distribution of smallpox cases and deaths in Mitford Hospital, Dacca, and in selected districts, East Pakistan, January–May 1958

| District | Males | | Females | |
|-------------------------|-------|--------|---------|--------|
| | Cases | Deaths | Cases | Deaths |
| Mitford Hospital, Dacca | 142 | 57 | 87 | 36 |
| Noakhali | 350 | 82 | 417 | 98 |
| Pabna | 478 | | 441 | |
| Dinajpur | | 247 | | 244 |
| Faridpur | | 238 | | 222 |
| Total | 970 | 624 | 945 | 600 |

The many religious sects and social groups of East Pakistan have sharply contrasting customs and habits of social behavior. Time did not permit a comparative study of the occurrence of smallpox in them and its relationship to population density and vaccination status. However, in conversations with local health officials the CDC team learned that some groups had responded poorly to vaccination campaigns and experienced high smallpox attack rates. Vaccination programs need to be intensified in localities where these groups reside.

From Control to Eradication

It has been said that when vaccination of 80 percent of the population has been achieved, smallpox will die out. In our opinion this is an oversimplification. In the more densely populated parts of East Pakistan it seems likely that a substantially higher percent of recently vaccinated persons would need to be achieved in order to eradicate smallpox by mass vaccination alone, and that this vaccination status would need to be maintained for several years.

Because of the extreme difficulty of accomplishing this in a country like East Pakistan, the surveillance phase of the eradication program should be introduced at an early stage—as soon, in fact, as the incidence of the disease has been reduced to a level where it becomes feasible to undertake emergency containment of each small outbreak as it occurs. Initiation

CDC Team

Members of the Communicable Disease Center team who participated in the collection and analysis of the data referred to in this paper were, in addition to Dr. Usher, Dr. Alexander Langmuir, chief, Epidemiology Branch of CDC; Dr. Frederick L. Dunn; Dr. Jacob A. Brody; Dr. Malcolm I. Page; Dr. Chandler R. Dawson; Dr. James W. Mosley; Dr. W. Yates Trotter; and Dr. H. Bruce Dull.

of this phase of the program should be timed to take advantage of the low incidence of an interepidemic period.

This is the manner in which smallpox was eradicated in the United States. Although it apparently was not accomplished by following a consciously conceived plan, what happened was that in the relatively sparse population of the United States it proved to be possible to reduce the density of susceptibles, and consequently the incidence of the disease, to a very low level by the vaccination of a smaller proportion of the population than would be necessary in East Pakistan. Thereafter it became possible to regard the occurrence of a case of smallpox as an emergency calling for immediate vaccination of the entire community. An especially dramatic example of this was the 1947 incident in New York City when the recognition of 12 cases of smallpox led to the vaccination of some 7 million people within a month.

In the surveillance or "firefighting" phase of an eradication program selective vaccinating of exposed persons (sometimes referred to as "ring containment") is, of course, desirable, but it is not considered advisable to rely entirely upon this for the emergency containment of outbreaks. This is especially true in a country like East Pakistan where health services are not fully developed, and there is a shortage of qualified health personnel for the performance of contact investigations. In such circumstances it seems essential to rely primarily upon "area containment," that is, an immediate, very intensive campaign to raise to the highest possible level the vaccination status of a community where an outbreak has occurred.

The successful execution of the "firefighting" phase of the eradication program in a country where the problem is as difficult as it is in East Pakistan may require rather drastic measures, such as area quarantine, during the time required to vaccinate a community in which an outbreak has occurred. Enforcement of emergency measures will need to be determined and persistent.

Is It Feasible?

Although the required strategic concept is simple and the technical procedures are not complex, the successful implementation of such a program in East Pakistan will not be easy. Traditionally, intensive vaccination activity there occurs only during epidemics. In interepidemic periods vaccinations continue at a more leisurely pace. To continue intensive vaccination activity when an epidemic is not raging would require understanding and sustained support by officials in the highest levels of the Government who have the responsibility of appropriating the funds to keep the work going. Furthermore, when it becomes necessary to apply drastic measures in the second phase of the program (the firefighting phase) there must be public understanding of the need for them.

Difficult problems of logistics also are involved. Transportation and communications facilities in East Pakistan are very poor. Personnel engaged in this program would need to be given priority use of those that are available, and funds are needed for purchase and repair of vehicles.

Where wet lymph is used, additional and improved facilities are needed for its refrigeration right up to the time when it is used in order to maintain its full potency. In some isolated sections of the country it seems essential that dried vaccine be used and perhaps consideration should be given to using dried vaccine exclusively. Whatever type of vaccine is used, it is essential that it be packaged in such a manner as to permit its satisfactory use by nontechnical personnel with little manual dexterity. For example, it is impractical to use a vaccine packaged in a vial that requires filing off a glass tip.

These are the requirements that appear to be crucial. The CDC team arrived at the opinion that the problems, although difficult, are not in-

surmountable. Eradication of smallpox in East Pakistan will be a difficult task, but it is considered feasible to undertake it at this time.

Summary and Conclusion

A proposal that the World Health Organization undertake a program of worldwide smallpox eradication is under study at the present time. The feasibility of such an undertaking under presently existing circumstances is dependent on the likelihood of success in countries where eradication is likely to be most difficult to accomplish and the obstacles greatest. One of these countries is Pakistan, in whose Eastern Province smallpox is deeply entrenched as an endemic and epidemic disease.

In 1958 a team of epidemiologists from the Communicable Disease Center of the Public Health Service was assigned to the International Cooperation Administration to participate in the assistance that the latter was extend-

ing to the Government of Pakistan in combating a smallpox epidemic in East Pakistan. Some of the observations of this team are pertinent to the question of whether it would be feasible at this time to attempt the eradication of smallpox in the Province.

It is concluded that such an undertaking is feasible at this time if certain problems are recognized and successfully dealt with. The concept of "density of susceptibles" is postulated, and certain other factors bearing on the problem are discussed. It is suggested that the strategic plan would need to be the same one that has led to the eradication of smallpox elsewhere, namely, reduction of prevalence by means of widespread vaccination, followed by surveillance and emergency containment of each outbreak as it occurs. For the latter it is believed that primary reliance should be placed on "area containment" rather than "ring containment."

PUBLICATION ANNOUNCEMENTS

Address inquiries to the publisher or sponsoring agency. WHO publications may be obtained from the Columbia University Press, International Documents Service, 2960 Broadway, New York 27, N.Y.

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