

SMALLPOX AND THE DENSITY OF SUSCEPTIBLE
PERSONS IN MATLAB, EAST PAKISTAN

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Smallpox is endemic in East Pakistan and major epidemics have frequently occurred. Figure 1 depicts the incidence of smallpox during the last two decades. There have been two major epidemics during this period, in 1951 and 1958. In 1961 an intensive eradication programme was started and continued until 1963. Following this programme, the number of reported cases fell sharply, reaching the lowest level in the past two decades. The number of cases reported was only 64 in 1964 and 316 in 1965. However, in 1966 the number of cases again rose to 3 200 and since that time has continued to rise, with 6 400 cases reported in 1967 and 9 200 cases in 1968.

The eradication programme carried out between 1961 and 1963 was a systematic and intensive effort. Mobile teams performed house-to-house vaccinations. Freeze-dried vaccine was used. The number of vaccinations recorded was 25 million in 1961, 27 million in 1962 and 22 million in 1963. The total number of vaccinations recorded during the campaign, 74 million, far exceeded the total population of 56 million in East Pakistan at that time. For 2 years it appeared that the campaign might obtain success, but this hope was short-lived (Figure 1). Though there have been no major epidemics since the campaign comparable to those of 1951 or 1958, the disease persists in endemic form.

Several factors must be examined as possible explanations for the failure of the eradication effort. First, the proportion of vaccinated persons in the population should be determined. Second, the vaccination coverage by age, sex, village and area should be evaluated. Third, it is essential to consider the population density, because the opportunity for transmission of smallpox is increased when large numbers of susceptible persons are in close contact, and lessened when they are widely separated.

In this discussion, the concept of density of susceptible persons is introduced and the problem analysed in this context. The density of susceptible persons is defined as the number of susceptible persons per sq. mile.

Individuals who have never been vaccinated are regarded as susceptible. Persons who have been vaccinated some years previously may become susceptible with the passage of time, but the role which such people play in transmission is regarded as much less important, both because they are far less likely to develop smallpox than the unvaccinated and also because they probably are less effective in transmission of the infection. For these reasons only the unvaccinated group is treated as susceptible in the discussion which follows. Furthermore, the analysis is limited to a rural population, which is quite evenly distributed over a large area.

Matlab Assessment Programme

An extensive assessment was conducted in Matlab, Comilla district, in 1967. This area, which is situated about 50 km. from Dacca, is considered to represent a typical rural population in the central part of East Pakistan. In the assessment, the vaccination status of the entire population was determined both by history and by scar survey. Of the 110 000 persons in the Matlab area, 103 539 were examined for the presence of vaccination scars.

Table 1 shows the percentage of persons with vaccination scars by age and sex. Eighty percent of the total population had vaccination scars. The percentage of persons with scars was highest in adults and fell progressively with age. In persons over 15 years of age the percentage with scars was 94%, in those between 10 and 14 years, 92%, and between 5 and 9 years, 80%. However, in the age group 0 to 4 years, only 34% had vaccination scars. Within this group the percentage with scars again diminished with age: 57% at age 4; 50% at age 3; 34% at age 2; 16% at age 1; and 6% in children less than one. There were no significant differences between the percentages of males and females with vaccination scars.

In the survey area there were 132 villages with an average population of 850 inhabitants. The frequency distribution of the percentage of persons with vaccination scars is shown by numbers of villages in Table 2. When all ages are considered together, more than half of the villages had populations in which 80% or more had scars and, in almost all villages, scars were present in more than 60% of the inhabitants. Very high percentages with scars were found in almost all villages in persons over 15 years and in the 10 to 14 year age group. However, in the age group 5 to 9 years, there was a greater scatter

in the coverage. In the age group 0 to 4 years, only a small proportion of villages had populations in which more than 50% showed scars.

These observations brought out two points of importance about vaccination coverage in this region. The first was the unsatisfactory level of coverage in the 0 to 4 year age group. The second was that, from village to village, while persons above 10 years of age had been well covered, there was a wide range of coverage in younger individuals, particularly those 0 to 4 years old.

Returning to the whole Matlab area, it was found that, of 103 539 persons examined, 19 844 did not have vaccination scars. These 19 844 persons, representing 20% of the population, were susceptible to smallpox. The figure of 80% coverage is quite high and in the past was regarded as an acceptable goal in eradication programmes. The remaining 20% of the population, however, provided a base sufficiently large to maintain smallpox transmission in Matlab and, in fact, in a retrospective study it was found that 119 cases occurred during 1967.

The total population density of the study area is high, 1 500 persons per sq. mile. Twenty percent of these were susceptible, thus the density of susceptible persons was 300 persons per sq. mile. In many countries where smallpox remains endemic, the total population density is far lower than this, and the density of susceptible persons is even lower as a result of vaccination. Many endemic countries with relatively low population densities have become smallpox free with overall vaccination coverage of far less than 80%, while others with very high rural population densities, such as East Pakistan and India, have failed to achieve eradication with coverage of 80% or more.

Much of East Pakistan has a population density comparable to that of Matlab. Comilla district, in which Matlab is located, with a total population of 5 000 000, has a population density of 1 900 per sq. mile. If the vaccination coverage is assumed to be the same as in Matlab, namely 80%, the density of susceptible persons would thus be 380 per sq. mile. In adjoining Dacca district, this figure would be even higher.

To illustrate this concept of the density of susceptible persons, Table 3 provides theoretical figures of the density of susceptible persons according to population density and vaccination coverage. As can be seen in Table 3, 80% vaccination coverage in a densely populated area with a population density

of 2 000 per square mile, leaves 400 susceptible persons per square mile.

This density of susceptible persons is found when only 20% vaccination coverage is achieved in a less populated area with a population density of 500 per square mile.

These observations indicate that, despite a reasonably high vaccination coverage of 80%, the remaining 20% of unvaccinated persons may be sufficient to maintain endemic smallpox because of the high density of susceptibles.

Therefore, in planning and assessment of an eradication programme in densely populated areas, it is important to consider the situation not only in terms of the percentage of the population which has been vaccinated, but also in terms of the number of persons who remain susceptible; for it is in this group that smallpox will continue to smoulder. The number of susceptible persons may be examined, with calculation of density of susceptible persons per square mile or km. in a given operation unit area.

Experiences in Madras State and in Indonesia in the 1930's, when that area was free of smallpox, suggest that if the density of susceptibles is reduced to 50 or less per square mile, transmission tends to cease. Further studies, however, are necessary.

In East Pakistan, and in many other countries, the susceptibles are concentrated in the youngest age group. In fact, 60% of susceptible persons observed in the Matlab area were in the age group 0 to 4 and 20% in the group 5 to 9 years. Therefore, the best strategy to reduce the density of susceptible persons is to vaccinate the children in these groups rather than to continue to administer superfluous revaccinations to very large numbers of adults, most of whom are already immune.

(Data regarding Matlab assessment programme were provided by Pakistan-SEATO Cholera Research Laboratory, Mohakhali, Dacca, East Pakistan)

TABLE 1

FREQUENCY OF VACCINATION SCARS BY AGE AND SEX

Age (years)	Total No. Examined	% persons with vaccination scar		
		Total	Male	Female
Under 1	3 356	6.1	5.9	6.4
1	3 350	16.9	16.3	17.6
2	3 473	34.8	34.6	35.2
3	4 012	50.2	50.6	49.9
4	4 209	57.3	56.7	57.9
0-4	18 400	34.8	34.6	35.2
5-9	19 995	80.2	79.9	80.5
10-14	14 278	92.3	93.0	91.4
15+	50 798	94.5	95.6	93.6
Unknown	68	73.5	85.2	67.8
Total	103 539	80.8	80.3	81.2

TABLE 2

FREQUENCY DISTRIBUTION OF NUMBER OF VILLAGES
ACCORDING TO THE PERCENTAGE OF VACCINATION
SCARS BY FOUR AGE GROUPS

% persons with vaccination scar	Age groups				
	All ages	0 - 4	5 - 9	10 - 14	15+
0 - 9	0	6	1	0	0
10 - 19	0	18	0	0	0
20 - 29	0	23	0	0	0
30 - 39	1	36	2	1	0
40 - 49	0	22	2	0	1
50 - 59	0	19	10	0	0
60 - 69	13	7	13	1	0
70 - 79	45	1	24	8	0
80 - 89	64	0	45	29	22
90 - 100	9	0	35	93	109
Total	132	132	132	132	132

TABLE 3

DENSITY OF SUSCEPTIBLE PERSONS PER SQUARE MILE
BY VACCINATION COVERAGE

Population density per square mile	Number of susceptible persons when vaccination coverage of population is:				
	20%	40%	80%	90%	95%
2000	1600	1200	400	200	100
1000	800	600	200	100	50
500	400	300	100	50	25
300	240	180	60	30	15
100	80	60	20	10	5

FIGURE 1

SMALLPOX INCIDENCE, EAST PAKISTAN 1950-1968

