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TRANSMISSION OF SMALLPOX IN ENDEMIC AREAS

by

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At the start of 1969, 27 countries in the world were considered to be smallpox endemic areas, and these accounted for over 99 per cent. of the world's smallpox. By definition, an endemic area is one in which a certain minimum number of smallpox cases appear each year - we may say arbitrarily an average of at least 50 reported cases a year. What this means is that smallpox is constantly present in the area concerned and is being transmitted, even though the cases may not be detected and reported month by month.

This paper deals with some of the basic features of smallpox transmission in an endemic area, and will be illustrated with data from studies that have been carried out in West Pakistan during the past four years by the authors and by Thomas & Mack[1] as follows:

(a) Epidemiologic investigations of smallpox in Sheikhupura District, West Pakistan, 1966-67. In these studies, an attempt was made by intensive surveillance to detect and characterize all outbreaks that occurred in a single rural district (population: 1.1 million) over a period of one year.

(b) Survey of Lahore Municipal Corporation, West Pakistan, 1968-69. A survey of vaccination status and past smallpox experience of an urban population.

(c) Epidemiologic studies in six districts of West Pakistan, 1968-69.

Susceptibility of the population

An over-all high level of vaccination (in terms of vaccination scar status) does not always mean that a population is adequately protected against smallpox. Even a relatively well-vaccinated population may have substantial numbers of unvaccinated susceptibles in the youngest age-groups; and these may be more than enough to ensure transmission of disease and to sustain an endemic level of smallpox. Furthermore, an unknown but considerable number of persons who have been vaccinated may have again become susceptible as their immunity has waned.

In a survey of Lahore, West Pakistan, in 1968-69 (Table 1) only 9.9 per cent. of persons examined had no vaccination scars and only 7.1 per cent. had no vaccination scar or smallpox scar. This represents a relatively high level of immunization. However, one finds that 60.6 per cent. of infants, 15.6 per cent. of children one to four years of age and 4.6 per cent. of children five to nine years of age were still fully susceptible.

[1] Mack, T. M. & Thomas, D. B.

Persons at greatest risk

In all endemic areas, children represent the majority of susceptibles - and hence the majority of cases. Table 2 gives a breakdown of all smallpox cases detected in a one-year period (1966-67) in Sheikhupura District, West Pakistan. Of 898 cases 55.7 per cent. were children less than 10 years of age. Attack rates for school-age children (five-to-14 years) not attending school (and thus less accessible to vaccinators) were six times higher than attack rates of children at school.

The great majority of cases occur in the unvaccinated, although a number of cases also occur in persons who have been vaccinated, usually sometime in the distant past. In the Sheikhupura studies, 12.9 per cent. of cases were known to have vaccination scars but, as some could not be examined, the total number was undoubtedly higher.

Infants as a group should be considered as susceptible from birth. Studies in West Pakistan in 1968-69 indicate that maternal antibody protection is highly variable and therefore undependable. Cases have been noted in infants as young as two months.

Transmission of smallpox to contacts

Once a case of smallpox appears in a locality, transmission occurs primarily among close contacts of the case; and the extent of immunity among these contacts will largely determine the further course of the outbreak.

Among household and compound contacts of smallpox cases in 47 outbreaks (Table 3), the attack rate of unvaccinated contacts was 65.7 per cent ., while that of previously vaccinated contacts was only 4.3 per cent. Of 30 persons who had previously experienced smallpox, no cases occurred. This demonstrates the highly protective effect of vaccination, even in persons who may have been vaccinated only in childhood. Preliminary results of these studies also appear to confirm the effectiveness of vaccination or revaccination soon after exposure.

Characteristics of outbreaks

Smallpox is not a highly infectious disease, and its spread both within a locality and between localities is usually low. In an endemic area, most of the outbreaks are small, most are of short duration, and many burn themselves out without further spread. On the other hand, the very fact that transmission is slow means that an outbreak may continue to smoulder for many months if not detected, thus representing a persistent focus of infection.

In the studies in Sheikhupura District, more than a quarter of the 120 outbreaks detected consisted of one case only and over 60 per cent. consisted of five cases or less (Table 4). One-third of the outbreaks had only import cases, with no further transmission. In those in which further transmission did occur, the average duration of an outbreak was 50 days. However, some of the outbreaks continued for two months, three months and even longer.

Transmission of smallpox between localities

The pattern of spread of smallpox will vary in different endemic areas. However, there is a general tendency for cities to serve as foci of infection and thus to generate a disproportionate number of outbreaks in surrounding areas.

Among outbreaks of known source in Sheikhupura District in 1966-67, more than a quarter could be traced directly to cities and more than half could be traced directly or indirectly to cities (Table 5).

"Carriers" of smallpox between localities can also be identified. In Sheikhupura, 56 per cent. of outbreaks of known origin were initiated by children under 15. At least 50 per cent. and probably nearly 80 per cent. of the outbreaks were caused by import cases who were unvaccinated.

Seasonal incidence of smallpox

Smallpox has a very marked seasonal pattern in endemic areas, although the exact pattern varies from region to region. Throughout West Pakistan, there is a peak in winter and early spring and a very low ebb in summer and early fall (Figure 1).

On the other hand, the course of smallpox outbreaks may be very erratic within a given country and from year to year. The disease may disappear temporarily from certain districts, and its reappearance will then depend both on the accumulation of sufficient numbers of susceptibles and on the development of adequate foci of infection in adjacent districts.

Conclusions

This examination of the patterns of transmission of smallpox in endemic areas has many obvious lessons for smallpox eradication:

1. The unique patterns of smallpox transmission provide excellent opportunities for eradication efforts. At any given time, only a relatively small percentage of localities in an endemic area are affected; and the spread of the disease is usually slow, both within a locality and between localities. Thus, with adequate surveillance and follow-up operations, it often is a relatively easy task to break the chains of transmission. The marked seasonal pattern of smallpox provides an additional advantage; the detection and control of only a few outbreaks during the months of low incidence may serve to forestall most or all potential outbreaks in an area during the following smallpox season.

2. Over-all vaccination scar status is not always a reliable index of the susceptibility of a population to smallpox. Even in a relatively well-vaccinated population, there may be large groups of susceptibles, consisting primarily of unvaccinated infants and children but also including some vaccinated persons whose immunity has waned.

3. An eradication programme should include an adequate emphasis on cities, since urban areas tend often to be persistent foci of infection and thus play a disproportionate role in generating smallpox outbreaks in surrounding areas.

4. The value and importance of vaccination in preventing smallpox is amply demonstrated in studies of household contacts, who are the persons at highest risk. Attack rates in the unvaccinated are 15 times as high as in vaccinated contacts.

5. Studies in West Pakistan indicate that unvaccinated children who are not attending school constitute a major single group of susceptibles. Effective vaccination coverage of this group alone would eliminate about two-thirds of the potential smallpox cases in an area, and also the most important carriers of the disease between localities.

TABLE 1. SUSCEPTIBLES - SCAR SURVEY - LAHORE MUNICIPAL CORPORATION - 1968-69

(a) Persons without vaccination scars

Age	Percentage without vaccination scars
Less than 1	60.6
1-4	15.6
5-9	5.6
10-19	3.4
20 and above	8.9
Total	9.9

(b) Persons without vaccination scars or scars of smallpox

Age	Percentage without vaccination scars or smallpox scars
Less than 1	60.6
1-4	15.6
5-9	4.6
10-19	2.2
20 and above	3.5
Total	7.1

TABLE 2. SMALLPOX CASES BY AGE, SCHOOL ATTENDANCE AND VACCINATION STATUS SHEIKHUPURA DISTRICT, WEST PAKISTAN, 1966-67

(a) Distribution of cases by age

Age	Cases	
	No.	% of total
Less than 1	58	6.5
1-4	201	22.4
5-9	241	26.8
10-19	229	25.5
20 and above	169	18.8
Total	898	100.0

(b) Attack rates per 10 000 by school attendance* for children of age 5-14 years

Attending School	No. of Cases	Attack Rate
Yes	28	3.0
No	349	19.2
Unknown	4	-
Total	381	13.9

*Based on 1961 census

(c) Distribution of cases by vaccination status

Vaccination status	Cases	
	No.	% of total
Scar	134	12.9
No scar	543	52.2
Probably no scar*	164	15.8
Unknown	199	19.1
Total	1 040	100.0

*Cases which died or had confluent lesions preventing examination for vaccination scars

TABLE 3. ATTACK RATES BY VACCINATION STATUS FOR HOUSEHOLD AND COMPOUND CONTACTS OF THE FIRST CASE - 47 OUTBREAKS IN WEST PAKISTAN, 1968-1969

Vaccination status	No. of contacts	No. of secondary cases	Attack rate (%)
Smallpox scars	30	0	0.0
Vaccination scar	277	12	4.3
No scar	70	46	65.7
Uncertain*	16	16	-
Not examined	50	5	10.0
Total	413	79	19.1

* Died or had confluent lesions preventing examination for vaccination scars

TABLE 4. CHARACTERISTICS OF OUTBREAKS
SHEIKHUPURA DISTRICT, WEST PAKISTAN, 1966-67

(a) Size of outbreaks: Distribution of outbreaks by number of cases

No. of cases	Outbreaks	
	No.	% of total
One case only	33	27.5
2-5	40	33.3
6-10	26	21.7
More than 10	21	17.5
Total	120	100.0

(b) Duration of outbreaks: Distribution of outbreaks by duration in days

Duration in days	Outbreaks	
	No.	% of total
Less than 10 days (import cases only; no transmission)	40	33.3
10-19 days	16	13.3
20-39 days	28	23.3
40-59 days	12	10.0
60-99 days	13	10.8
100 and above	11	9.2
Total	120	100.0

TABLE 5. TRANSMISSION OF SMALLPOX BETWEEN LOCALITIES, SHEIKHUPURA DISTRICT, WEST PAKISTAN, 1966-67

(a) Source of outbreaks: Distribution of outbreaks of known source by size and location of source locality

Source	Outbreaks	
	No.	% of total
Direct urban source*	20	27.8
Indirect urban source	18	25.0
Direct or indirect urban source	38	52.8
Other	34	47.2
Total with known source	72	100.0

*Urban = localities with more than 100 000 population

(b) Import cases by age and sex (in outbreaks of known origin)

Age and Sex	Import cases	
	No.	% of total
Under 15 (both sexes)	42	56.0
15 and above (male)	22	29.3
15 and above (female)	11	14.7
Total	75	100.0

Figure 1. SEASONAL DISTRIBUTION OF SMALLPOX CASES
SHEIKHUPURA DISTRICT, WEST PAKISTAN, 1966-1967