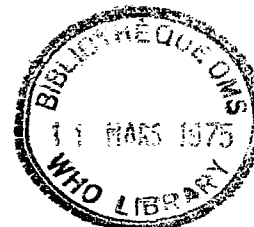PATTERN OF INTRAFAMILIAL TRANSMISSION OF SMALLPOX
IN THE CITY OF CALCUTTA[1]

by

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Although the smallpox immunity status of an individual is primarily responsible for determining his susceptibility to infection, the immune status of the population in general and other environmental factors ultimately decide the disease pattern in an area.   It is, therefore, natural that the pattern will vary from place to place.

Calcutta, a city of multi-storied buildings interrupted by slum areas, has been known as the home of smallpox for decades.   Because there is no dearth of susceptible persons in the city, infection usually involved several members of a family or several houses in a locality. In the work to be presented here, the spread of smallpox amongst family members after introduction of infection has been studied.

Materials and methods

The families of 43 virologically proved smallpox cases admitted to the Infectious Diseases Hospital (I.D.H.) Calcutta, during 1971 and 1972 were studied.   In addition, the families of cases detected during visits to the affected areas were included in the study group.   The first cases in each of the families constituted the group of "index" cases.   Usually the hospitalized cases were the index cases, but in a few instances, they were secondary cases and the index cases could only be examined during convalescence.   The relevant particulars of all index cases were recorded on specially prepared Index Cards.

The word "contact" in the present work denotes a person belonging to the family of a smallpox case and who lives in the same house or same compound with the index case.   All family contacts of index cases were enumerated and the particulars of every "contact" were noted.   The affected families were visited frequently to detect new cases occurring within a period of one month after the onset of fever of the index case in the family.   The day of onset of the disease was calculated from the day of onset of fever.

Persons with vaccination marks were labelled as "vaccinated".   No attempt was made to elicit a history of revaccination or time of primary vaccination, as reliable information of this sort could not be procured.   Persons with no mark of primary vaccination or vaccinated within seven days prior to the onset of illness were regarded as "unvaccinated".

To denote the severity of the disease, the index cases were divided into categories as follows: (1) haemorrhagic, (2) confluent, and (3) discrete, as per criteria used by Sarkar & Mitra (1967). The haemorrhagic cases were the most severe and the discrete cases the least. For purposes of comparison of secondary attack rates when the number of haemorrhagic cases was too small to be considered alone as a group, the haemorrhagic and confluent cases were taken together as severe cases and the discrete cases, as mild.

The areas affected by smallpox were generally the slum areas, where the houses consist of compounds or open spaces surrounded by five to seven rooms, each living room being occupied by a "family" (multiple family compound). Very rarely, a family had more than one room or a separate compound (single family compound). In each compound, family members freely mixed amongst themselves.

The term "secondary" case in this work has been used to denote only first generation cases.

Results

Secondary attack rates following exposure to "haemorrhagic", "confluent" and "discrete" cases are shown in Table 1. There is a slight gradient in the secondary attack rates of those exposed to haemorrhagic, confluent and discrete index cases, the attack rates being 17.7, 16.0 and 13.3% respectively. The significance of this is difficult to assess as the number of contacts per index case for each of the groups varied greatly (30.0, 14.3 and 17.3 respectively). However, when the cases are divided into two groups, those occurring in single family compounds and those occurring in multiple family compounds (Table 2) the average numbers of contacts per index case are similar for each group. Hence, all subsequent comparisons are based on separate analysis of cases and contacts in single family compounds and multiple family compounds.

Secondary attack rates according to the severity of the index cases amongst the vaccinated and unvaccinated contacts in the "single family compounds" and "multiple family compounds" are shown in Table 3. In both groups there are highly significant differences in the attack rates between vaccinated and unvaccinated contacts, but there is little difference in the secondary attack rates among those exposed to severe (haemorrhagic and confluent cases) and mild index cases, either among vaccinated or unvaccinated contacts.

Secondary attack rates by age and vaccination status among male and female contacts in single family compounds are shown in Table 4 and in multiple family compounds in Table 5. The numbers in each of the separate categories are small, making it difficult to draw conclusions in regard to relative risks by age. However, no consistent pattern of differences in secondary case rates according to age group of the index case is apparent. Females have consistently higher attack rates than males in almost all age groups. Amongst the vaccinated contacts in the multiple family compounds, the attack rate of 4.7% amongst males is significantly lower than 9.8% amongst females ($x^2 = 5.3$, P <0.05). Amongst the unvaccinated contacts in both the groups the attack rates among males and females are similar.

Table 6 shows the vaccination status of the 43 index cases. Only two of the severe cases had previously been vaccinated. With such small numbers, a comparison of relative risks among those exposed to previously vaccinated severe cases and those exposed to unvaccinated severe cases is not possible. However, a comparison amongst those exposed to previously vaccinated and unvaccinated discrete cases is shown in Table 7. Attack rates among those exposed to previously vaccinated discrete cases are not notably different overall than amongst those exposed to unvaccinated discrete cases.

Finally a comparison was made in the attack rates amongst contacts living in the same room with the index cases and those living in other rooms of the same compounds (Table 8). There is no significant difference in the attack rates between the two groups of contacts, either among the vaccinated or the unvaccinated.

Discussion

Spread of smallpox infection depends upon various factors such as the number of persons coming in contact with the case, their age, vaccination status, duration of contact, the clinical type of the index case, etc. Most of these factors depend upon the living conditions of the people which vary from place to place. However, it is important to know the pattern of spread of smallpox in each place, if the eradication of the disease from that place is contemplated.

In Calcutta, as in many other endemic cities, the focus of smallpox is usually those areas inhabited by people of low socioeconomic status. In these areas, resistance to vaccination and overcrowding help to maintain and spread infection.

That the different clinical types of varying severity have different capabilities of transmission of the disease has been reported by many (Heiner et al., 1971; Thomas et al., 1971; Mack et al., 1972; Report 1972). Rao et al. (1968) in India found that the most severe (i.e. haemorrhagic) and the mildest cases transmit infection less frequently than the ordinary and flat cases. Other workers conversely have emphasized the infectiousness of the milder case (Herrlich et al., 1960; Strom et al., 1966). In the present study, no significant differences in the secondary attack rates were found between the severe (haemorrhagic and confluent) and mild (discrete) groups of index cases. It is difficult to reconcile the findings of the present study with those of some of the previous workers. One of the reasons may be the difference in the clinical classification used by different workers. However, from the data presented by previous workers, the basis for their conclusions cannot always be clearly understood. From the elaborate paper of Rao et al. (1968), it appears that his haemorrhagic cases did not cause any secondary cases and six flat cases (severe) only produced one secondary case, whereas his ordinary and modified (milder) cases proportionately produced a greater number of secondary cases. In the series of Thomas et al. (1971), the severe cases were considered to be those who died and therefore their data are not strictly comparable with those of others. There being no mention of the number of index cases of different grades of severity in the series of Heiner et al. (1971), proper assessment of the statement that severe cases transmit infection more readily is not possible. In the data supplied by Mack et al. (1972), the number and vaccination status of the persons coming in contact with his severe and mild cases are not mentioned. Thus, the potential of spread of the disease, which depends on these two factors, cannot be properly assessed. Furthermore, in a study of this kind, only the first generation of secondary cases should be taken into account, as has been done in the present study. This criterion was followed by Thomas et al. (1971), but the point is not very clear in the reports of other workers. Although the haemorrhagic and confluent cases were found to contain more virus in their secretions (Sarkar et al., 1973), this does not seem to have influenced materially the spread of disease amongst their contacts.

The disease spread significantly more amongst the females than males. Rao et al. (1968) made a similar observation although the differences in his series were not statistically significant. The reason for the higher rates among females may be that females have less outdoor activities and, therefore, have more prolonged contact with the patients in the houses. On analysing the data according to age, the higher incidence in females has been noted in all age groups. There is a significant difference in the attack rates between vaccinated male and female contacts in all age groups in multiple family compounds, but little difference among unvaccinated contacts. In other words, the duration of exposure seemed to have bearing only on the risk to vaccinated contacts. In the present series, no consistent differences in risk by age were noted.

It has been said that smallpox cases with primary vaccination marks spread the disease less than the unvaccinated patients (Rao et al., 1968; Heiner et al., 1971). Differences of this sort in the present study in regard to the discrete groups of index cases were not obvious. In other words, the vaccinated person when he developed the disease, appeared to spread infection as well as the case who had no previous history of vaccination. This finding does

not in any way undermine the importance of vaccination in preventing the infection or reducing the severity of the cases. It is not clear whether in the consideration of this aspect by Rao et al. (1968) and Heiner et al. (1971), comparable numbers of vaccinated and unvaccinated index cases were considered. Living in the same room with the patient or in different rooms in the same compound, does not seem to influence the spread of smallpox infection among vaccinated or unvaccinated contacts. Heiner et al. (1971), in their studies in Pakistan villages also found that the attack rates among household and compound contacts were similar. The findings are not unexpected, because, due to the proximity of the rooms of different families and intimate mixing of the inmates of the compound, all the inmates may be considered to constitute a family.

ACKNOWLEDGEMENTS

Summary

To determine the pattern of intrafamilial transmission of smallpox in Calcutta, the families of 43 index cases were studied. Twenty-two index cases lived in single family compounds and 21 in multiple family compounds. Three of the index cases were haemorrhagic, 14 confluent and 26 discrete, and the contacts corresponding to these were 90, 200 and 451 and the secondary cases were 16, 32 and 60 respectively. There were highly significant differences in the attack rates between the vaccinated and unvaccinated contacts, but there was no difference in the secondary attack rates among those exposed to severe and mild index cases, either among vaccinated or unvaccinated contacts. Females had consistently higher attack rates than males in all age groups and this difference was more marked amongst the vaccinated. Vaccination status of the index cases made little difference in the secondary attack rates among their contacts. The secondary attack rates amongst contacts living in the same room with the patients or in other rooms of the compound was almost the same.

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TABLE 1.   NUMBER OF PERSONS COMING IN CONTACT
WITH DIFFERENT TYPES OF INDEX CASES AND CONTRACTING THE DISEASE

Type of index case	Total number	No. of contacts	No. of secondary cases	Attack rate (%)	Average No. of contacts per index case	Percentage of vaccinated contacts
Haemorrhagic	3	90	16	17.7	30	88.8
Confluent	14	200	32	16.0	14.3	88.0
Discrete	26	451	60	13.3	17.3	89.8
Total	43	741	108	14.5	17.2	89.2

TABLE 2.   AVERAGE NUMBER OF CONTACTS PER INDEX CASE IN SINGLE
FAMILY COMPOUNDS AND MULTIPLE FAMILY COMPOUNDS

Type of index case	Single family compounds			Multiple family compounds		
	No. of index cases	No. of contacts	No. per index case	No. of index cases	No. of contacts	No. per index case
Haemorrhagic	–	–	–	3	90	30.0
Confluent	9	53	5.9	5	147	29.6
Discrete	13	58	4.5	13	393	30.2
Total	22	111	5.0	21	630	30.0

TABLE 3.   SECONDARY ATTACK RATES ACCORDING TO SEVERITY OF INDEX CASE

(a) Single family compounds: Vaccination status of contacts							
Severity	No. of index cases	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
Confluent	9	45	6	13.3	8	6	75.0
Discrete	13	48	3	6.3	10	7	70.0
Total	22	93	9	9.7	18	13	72.2
(b) Multiple family compounds: Vaccination status of contacts							
Severity	No. of index cases	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
Haemorr-hagic and confluent	8	211	14	6.6	26	22	84.6
Discrete	13	357	24	6.7	36	26	72.2
Total	21	568	38	6.7	62	48	77.4

TABLE 4.   SECONDARY CASE RATES ACCORDING TO AGE AND SEX

(a) Single family compounds						
Males						
Age group	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
0 - 4	5	-	-	-	-	-
5 -14	9	1	11.1	4	4	100.0
⩾ 15	40	2	5.0	7	4	57.1
Total	54	3	5.6	11	8	72.7
Females						
Age group	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
0 - 4	4	2	50.0	4	3	75.0
5 -14	12	2	16.7	2	1	50.0
⩾ 15	23	2	8.7	1	1	100.0
Total	39	6	15.4	7	5	71.4

TABLE 5.   SECONDARY CASE RATES ACCORDING TO AGE AND SEX

Multiple family compounds						
Males						
Age group	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
0 - 4	53	2	3.8	14	9	64.3
5 -14	82	5	6.1	6	6	100.0
⟩ 15	209	9	4.3	11	7	63.6
Total	344	16	4.7	31	22	71.0
Females						
Age group	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
0 - 4	19	2	10.5	15	13	86.7
5 -14	60	6	10.0	5	5	100.0
⟩ 15	145	14	9.7	11	8	72.7
Total	224	22	9.8	31	26	83.9

TABLE 6.   CLINICAL TYPES OF DISEASE AND VACCINATION STATUS OF THE INDEX CASES

Type of index case	Vaccinated	Unvaccinated	Total
Haemorrhagic	Nil	3	3
Confluent	2	12	14
Discrete	13	13	26
Total	15	28	43

TABLE 7. VACCINATION STATUS OF INDEX CASE
(DISCRETE CASES ONLY) IN RELATION TO SECONDARY CASES

(a) Single family compounds							
Vaccination status	No.	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
Vaccinated	4	91	11	12.1	3	1	33.3
Unvaccinated	9	33	1	3.0	7	6	85.7
Total	13	124	12	9.7	10	7	70.0

(b) Multiple family compounds							
Vaccination status	No.	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
Vaccinated	9	166	13	7.8	33	23	70.0
Unvaccinated	4	91	11	12.1	3	3	100.0
Total	13	257	24	9.3	36	26	72.2

TABLE 8. SECONDARY ATTACK RATES AMONG CONTACTS LIVING
IN THE SAME ROOM WITH THE "INDEX CASE" AND THOSE IN
OTHER ROOMS IN MULTIPLE FAMILY COMPOUNDS

	Vaccinated contacts	Cases	Rate %	Unvaccinated contacts	Cases	Rate %
In the same room	79	8	10.1	21	15	71.4
In other rooms	489	30	6.1	41	33	80.5