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WHO/SE/71.24

ENGLISH ONLY

ENDEMIC SMALLPOX IN RURAL EAST PAKISTAN

I. Methodology, clinical and epidemiological characteristics of cases, and intervillage transmission[a]

by

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ABSTRACT

Thomas, D. B. (Johns Hopkins University, School of Hygiene and Public Health, Baltimore, Maryland, 21205), McCormack, W. M., Arita, I., Khan, M. M., Islam, M. S. & Mack, T. M. Endemic Smallpox in Rural East Pakistan I: methodology, clinical and epidemiological characteristics of cases, and intervillage transmission.

During one year, 119 cases of variola major, representing 30 outbreaks, occurred in 27 villages of a rural study area in East Pakistan. Nearly one-fourth of the cases died, the majority during the second week of illness. Pre-exposure vaccination reduced mortality. The case fatality ratio was highest for the nearly completely unimmunized cases less than age five, and higher for those under one than from one to four. The density of lesions on the arms and face of unvaccinated cases varied widely; previously immunized cases tended to have relatively sparse lesions. Highest attack rates were noted for the unvaccinated, especially five to 14 year-old males, and children not attending school. Most cases occurred in the spring. All were a result of introductions into the study area, primarily by landless adult males who frequently came from jobs in large cities where only 5 per cent. of the people

[a] This study, supported in part by a grant from the National Institutes of Health (TW00142), was a co-operative effort between investigators associated with the Pakistan Medical Research Centre in Lahore, West Pakistan, and the Pakistan - SEATO Cholera Research Laboratory (PSCRL) in Dacca, East Pakistan. Information provided by the Smallpox Eradication unit of the World Health Organization has also been incorporated in the data analysis. The assistance of Dr Wiley H. Mosley and Mr K. M. A. Aziz of the PSCRL, and the statistical advice of Dr Genell L. Knatterud of the University of Maryland, are gratefully acknowledged.

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in East Pakistan reside. Smallpox was introduced into villages with a frequency directly related to their population size. Selective vaccination procedures based on these findings can reduce the potential for intravillage smallpox spread, and diminish the probability of introductions into rural communities.

Key words: communicable diseases, communicable disease control, epidemiology, infectious diseases, smallpox, vaccination, virus diseases.

INTRODUCTION

Efforts to control smallpox date back to the latter half of the nineteenth century in some portions of the Indian Subcontinent, and universal or selective vaccination programmes have existed in all major areas since the 1930s. Yet, although incidence rates are much lower now than prior to these efforts, no portion of India or Pakistan can safely be regarded as free of smallpox today. Within the past decade, the governments of these two countries have initiated new smallpox eradication programmes. However, if these new efforts represent no more than an indiscriminate increase in the number of vaccinations performed, without consideration of factors which have enabled the variola virus to survive in the presence of past vaccination programmes, then they are likely to fail.

This study was designed to provide a description of the spread of smallpox into and within communities of a rural area of Bengal in East Pakistan. The results of this endeavour, presented in two parts, provide evidence to support the hypothesis that factors amenable to human intervention exist which, if altered, could result in the eradication of smallpox without relying on universal vaccination and revaccination of the rural masses. The methods used, the clinical and epidemiological characteristics of the cases, and the intercommunity spread of variola are described in this first part. The intravillage transmission of smallpox and the infectiousness of individuals with variola major are described in part 2.[1]

METHODS

The study area

The Pakistan - SEATO Cholera Research Laboratory (PSCRL) vaccine field trial area, located in the Chandpur Sub-division of Comilla District in East Pakistan, was the site of the study. Detailed descriptions of the area, which is located about 40 miles from Dacca, have been provided elsewhere.[2,3] It is typical of the Brahmaputra-Ganges-Meghna delta region, being flat, only a few feet above sea level, traversed by numerous tidal canals and rivers, and subject to flooding during the summer months. The nearly 113 000 inhabitants of the area live in 132 small rural villages, scattered over approximately 75 square miles of intensely cultivated land. Rice is the staple crop. During flood season, villages are frequently accessible only by boat. There are few roads.

All individuals who share common cooking facilities constitute a family, the members of which sleep in usually one, but sometimes more, small houses. Groupings of patrilineally related families form a bari. Villages are composed of baris, which may be contiguous or widely separated by canals and rice fields. Eighty per cent. of the people of the study area are Muslims, 20 per cent. are Hindus. Adherents to these two religions tend to live in separate villages or in separate baris of the same village.

Vaccinators have been employed for over 40 years by the health department of the district in which the study area is located. These individuals periodically travel to all villages within their designated area of responsibility to vaccinate infants whose births had been registered since their last visit. They also vaccinate an undetermined number of previously immunized individuals. Vaccinations are administered using a rotary lancet. Two circular lesions are usually made on each upper arm, which result in large easily visible scars.

In the early 1960s, all of Comilla district was included in a pilot programme to eradicate smallpox. Extra vaccinators were employed, and large numbers of people of all ages were vaccinated. Because of these efforts, the proportion of individuals greater than five years old who have been vaccinated may be greater in the study area than in some other parts of the country.

Epidemiological methods

An active surveillance system for cholera had been established in the study area prior to the present investigation.[4] Field workers, usually women village residents, visit each family daily to identify all individuals with diarrhoea. In June 1967, toward the end of the usual smallpox season, these workers were instructed to question at least one responsible adult in each family and identify all persons with a history of either smallpox or chickenpox during the preceding year. All cases were classified by the worker as definitely smallpox, definitely chickenpox, or of uncertain diagnosis.

In July 1967, visits were made to all localities from which smallpox cases or cases of uncertain diagnosis were reported, and to five villages from which only chickenpox was reported. The home of each reported case was visited. A diagnosis was made by history and physical examination for cases present during the visit. For cases unavailable to the investigators, a diagnosis was established by a clinical history taken from adult relatives and by the identification of an epidemiological relationship to other cases.

An outbreak was defined as a single case, or two or more epidemiologically related cases of smallpox occurring in the same village. Each outbreak judged by the investigators to be of smallpox with cases that occurred between 1 July 1966 and 30 June 1967 was investigated in a standardized manner. A precoded form was completed for each case. Age, sex, schooling experience, and religion were recorded, as was the occupation of the family breadwinner. The date symptoms began and the duration of the pre-eruptive prodrome were determined. The day of death was recorded for all fatal cases. The dates of primary and most recent vaccinations, if any, were obtained. All available cases were examined for vaccination scars. The following definitions were used to classify each case according to the density of lesions on his face and one forearm:

Lesion density class	Name	Lesions on face	Lesions on 1 forearm between wrist and elbow
1	Confluent	25% contiguous	25% contiguous
2	Semiconfluent	25% contiguous	25% contiguous, 100 lesions
3	Moderate	25% contiguous	25% contiguous, 100 lesions
4	Discrete	25% contiguous	25% contiguous, 20-99 lesions
5	Sparse	25% contiguous	25% contiguous, 0-19 lesions

An attempt was made to identify the case in each outbreak responsible for introducing smallpox into the village. The location of his exposure was ascertained, and the means, duration, and purpose of his travel determined. Cases who travelled while ill were differentiated from those who travelled during the incubation period of their disease.

One hundred and eighteen of the 132 villages in the study area are in Matlab Bazar Thana, which is an administrative sub-unit of Chandpur sub-division with a population of about 300 000. The remaining 14 villages are in adjacent Thanas. A tabulation of all officially reported cases of smallpox in Matlab Bazar Thana since 1930 was procured from the local health officer. To compare the case detection system utilized by the present investigators with the official reporting system, detailed official reports of smallpox occurring in the study area during the year of the investigation were also obtained from this same source.

Sources of demographic data

A census of the study area was taken in March and April of 1966, and births, deaths, in-migrations and out-migrations have subsequently been registered.[3] The distribution by age, sex, refugee status, religion, and literacy status of the population of each village, and the adjusted mid-year population of the area, calculated for the calendar year beginning 1 May 1966, were obtained from this source.

The number of children attending school in the study area population was estimated from the 1961 government census of Chandpur sub-division.[5]

In the spring of 1967, prior to this investigation, a vaccination survey was conducted in most parts of the study area.[6] Field assistants who normally supervise those who do cholera surveillance, examined all available individuals for smallpox vaccination scars. Individuals with previous smallpox were not identified, but were included in the survey.[a] Adults were questioned to determine the date each individual received his primary vaccination, and to ascertain who had been revaccinated in 1966 or 1967.

Supervisory PSCRL personnel also conducted a survey to provide descriptive information for each village. Villages were classified as compact, scattered, or intermediate according to the accessibility during flood season of the baris of which they were composed. Compact villages consisted of baris which were all accessible by foot during the wet season; all baris of scattered villages could be entered only by boat at that time; and intermediate villages were composed of baris of both types. The presence of medical facilities, post offices and schools was recorded for each village. The proximity to a scheduled launch service and to a paved road was ascertained, and the means of access to each village during the wet and dry seasons was determined.

Data analysis

Unless otherwise stated, differences in rates or distributions were considered significant if the appropriate statistical test showed the probability of their occurrence by chance alone to be 0.05 or less.

RESULTS

Background

In Matlab Bazar Thana five periods of relatively high smallpox incidence were reported from 1930 through 1967. These periods occurred every six to eight years. The present investigation was conducted during the last one. Neither the mean number of cases nor fatalities per year, calculated for each eight-year period since 1930 and for the five-year period ending in 1967, showed a discernable trend with time. There is consequently no evidence that the study period was atypical of previous years regarding the incidence of smallpox.

Vaccination status of the population

Over 105 000 people in the study area were included in the vaccination survey. Greater than 98 per cent. of the total population of the area surveyed, and more than 97 per cent. of each age and sex group were examined. Of 103 539 people examined, 19.2 per cent. exhibited no evidence of previous successful vaccination. As shown in figure 1, the proportion of unvaccinated individuals of both sexes decreased sharply with age from over 90 per cent. for infants to about 8 per cent. for 10 to 14 year-old children. The proportion without scars varied little by age for people older than 14. Beyond age 10, slightly fewer females than males had vaccination scars.

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[a] Based on attack rates and the case fatality ratio observed during this investigation, only four (1.7 per cent.) of the 239 people without vaccination scars in affected baris were estimated to have previously had smallpox.

Case detection

One hundred and nineteen smallpox cases were found to have occurred during the study period. They represented 30 outbreaks located in 27 different villages, which were widely scattered throughout the study area. Outbreaks ranged in size from one to 20 cases, and the mean size was four. In 22 outbreaks, all cases were confined to a single bari.

The occurrence of smallpox was confirmed by the investigators in all 20 localities in which the field workers reported smallpox. Seven of the 11 villages in which cases of uncertain diagnosis were reported were judged to have outbreaks of variola; in the four others chickenpox was detected. No smallpox cases were found in the five villages investigated from which only chickenpox cases were reported. This observation, plus the fact that only one officially reported smallpox case was not detected by the investigators, suggests that the means of case detection utilized in this investigation was reasonably complete.

Diagnosis and clinical characteristics

As shown in figure 2, most cases occurred in the spring, from two to three months prior to the investigation. Consequently, cases in only 12 outbreaks were observed while acutely ill. Individuals with pock marks of recent origin, or a history of a person dying with a rash compatible with that of variola, served to establish the diagnosis of smallpox in at least one case in 13 other outbreaks. A clinical history given by close relatives of absent convalescent cases, and the establishment of epidemiological links to known foci of smallpox were used to establish the occurrence of five additional, small, outbreaks.

Sixty-seven cases were examined, 29 had died prior to the investigation, and 23 were living but not present in their village during the study. Table 1 shows the age distribution of four groups of cases: those examined with and without vaccination scars and those not examined who died and who survived. Table 2 shows the distribution of individuals in these four groups by the number of years lapsing since primary vaccination. All examined cases with scars gave a history of primary vaccination and over three-fourths of the examined cases without scars denied ever having been immunized against smallpox. However, nine unscarred cases either gave an erroneous history of immunization or developed no permanent scar following vaccination. Consequently, a negative history of vaccination is likely to be relaible, but some cases from whom a positive history was obtained probably had not been successfully vaccinated.

The age distribution of the 23 unexamined survivors resembles that of the known scarred cases. Most were adult males who were working outside the village during the investigation. A negative vaccination history was obtained for six of these cases, and 11 others (three of whom had been revaccinated in the interim) had allegedly been initially vaccinated more than 20 years prior to their illness. None had received their primary vaccination less than four years before contracting smallpox.

The age distribution of cases not examined because of death resembles that of known unscarred cases, although skewed more toward the younger end of the age spectrum. Only two of the 24 fatal cases for whom a history was obtained were alleged to have ever been vaccinated. One of these had received his primary vaccination from 10 to 20 years previously, the other more than 20 years prior to his illness. The former had a history of revaccination from one to three years prior to illness, the latter had never been revaccinated.

As shown in table 3, nearly one-fourth of the cases died. Previously vaccinated cases are defined as those examined with vaccination scars plus those not examined with a history of primary vaccination. Unvaccinated cases are those examined without vaccination scars plus the unexamined with a negative vaccination history. The case fatality ratio was almost five times higher for the unvaccinated than the vaccinated. Case fatality ratios were highest for the uniformly unvaccinated infants and the next highest for one to four year-old, only one of whom had been vaccinated (and who survived). No trend in this ratio is discernible among the older cases. The mortality experience of the two sexes was similar. Fifty-five per cent. of all deaths occurred during the second week of illness, 21 per cent. occurred prior to this time, and the others occurred from three to six weeks after the onset of symptoms.

One half of all affected individuals had three days of pre-eruptive symptoms, and the prodrome lasted from two to five days in 88 per cent. of the cases. Prodrome duration did not vary with vaccination status. The distribution by lesion density class of the 34 cases seen close enough to the acute stage of their illness to be classified was unimodal: five, eight, 13, five and three cases were classified as being of lesion density classes one through five respectively. All but three of these 34 cases had neither vaccination scars nor a history of primary vaccination. The three previously vaccinated cases were one each of lesion density classes two, four and five. Only one of the 67 examined cases had a corneal lesion.

Rates of disease

Table 4 shows age specific attack rates for both sexes and for those who had and had not been previously vaccinated. Figure 3 shows age and sex specific attack rates for the total population, for the unvaccinated, and for the latter group with the exclusion of individuals who were known to have contracted their infection outside their own village. Previously vaccinated and unvaccinated cases were defined as in table 3. Denominators were estimated by multiplying the proportion surveyed with and without vaccination scars for the age and sex groups shown, by the adjusted mid-year population of these groups for the calendar year beginning 1 May 1966. As the number of previously vaccinated cases may be erroneously high, the attack rates shown are maximum estimates for vaccinated people and minimum estimates for the unvaccinated. In spite of this potential error, the overall attack rate was ten-fold greater for the unvaccinated than for the vaccinated.

Attack rates varied significantly by both age and sex, but not in the same manner as the prevalence of unvaccinated people in the population. The explanation for this observation can be seen from figure 3, if one assumes that differences in attack rates for various groups of unvaccinated, and presumably uniformly susceptible, individuals represent differences in the risk of exposure to variola. The rate for unvaccinated children under five was relatively low compared to that of other age groups, suggesting that the high total rate for this group was solely a result of a high prevalence of unvaccinated people. The five to nine year-olds were better vaccinated than the younger children, but had a slightly higher rate of smallpox. The higher attack for the unvaccinated of this age suggests that this higher total rate is a result of a greater risk of exposure. The risk of exposure of 10 to 14 year-olds was almost the same as for those from five to nine, the lower total rate for the former presumably being a result of a higher prevalence of acquired immunity.

The differences in total attack rates for males and females over four can similarly be shown to have resulted from differences in risk of exposure. When cases who contracted their infection outside the affected village were excluded, the sex differences in attack rates for the unvaccinated persisted for the five to 14 year-olds, suggesting that such differences are primarily a result of variations in the risk of intravillage exposure. For adults, however, the absence of a sex difference in attack rates upon the exclusion of introducers of smallpox into villages suggests the difference in total attack rates for the two sexes to be solely a result of a higher risk of exposure to variola outside the village experienced by men.

Attack rates for the vaccinated showed a slight increase with age.

For five to nine, 10 to 14 and 15 to 19 year-old children of each sex, attack rates were higher for children not in school than for schoolchildren. However, only 12 cases attended school, and none of the differences were statistically significant.

Only three of the 119 cases were Hindus, and the attack rates for Hindus and Muslims were 12.5 and 1.4 per 10 000 respectively.

Introduction into villages

The origin of 22 of the 30 outbreaks was determined. Twenty-four individuals were identified whose intercommunity travel resulted in the transportation of variola virus into a village. These introducers include two pairs of individuals who travelled together and contracted smallpox at the same location.

The seasonal distribution of introductions is shown in figure 2. The largest number occurred from two to four weeks prior to the peak incidence of smallpox in late April and early May. None occurred during late summer, autumn and early winter. The age and sex distribution of the 24 introducers differed significantly from that of the general population. Males over 15 years-old were over-represented (54.2 per cent. of introducers, 26.1 per cent. of population), and females of the same age were under-represented (8.3 per cent. of introducers, 25.7 per cent. of population).

Table 5 shows the distribution of all cases and introducers by family occupation group. The first group includes unskilled and semi-skilled agricultural and non-agricultural workers, tenant farmers, beggars and the unemployed. The second group includes artisans and craftsmen, merchants, entertainers, religious officials, and people in government service. Land owners constitute the third group. The distribution of the total population by occupation is unknown, but a very high proportion derive their livelihood directly from the land. Two-thirds of the introducers were of families of unskilled or semi-skilled workers, and one-third were of families of skilled workers or merchants. None were of families of land owners. This distribution varies significantly from that of the other cases, over 30 per cent. of whom were of land-owning families, and less than half of whom were of families of unskilled or semi-skilled workers.

Two of the 24 introducers were Hindus, a number not significantly different from the expected of 4.8 estimated by multiplying the proportion of Hindus in the population of the study area (20 per cent.) by 24.

The place of origin of an outbreak is defined as the community in which the introducer was exposed to variola. The origin of 21 of the 22 outbreaks of known source was outside the study area, transportation of the virus between two villages within the area was only documented once. As shown in table 6, 68 per cent. of the outbreaks of known source were traced to cities of over 100 000 people, where, according to the 1961 government census, only about 5 per cent. of the population of East Pakistan reside. The expected numbers of outbreaks shown were calculated by assuming that the relative probability of an outbreak having an origin directly traceable to a locality of a given size is equal to the proportion of people living in communities of that size. The distribution of the observed and expected numbers of outbreaks differ significantly.

Fourteen of the 24 introducers had travelled to the source locality for employment, and eight for family visits. Twenty-one had travelled by launch or boat, two by train, one by palanquin. Half of the introducers had been away from their village for more than one month, half for less. Eleven returned to their village while acutely ill to be cared for by relatives, 13 returned during the incubation period of their disease for other reasons.

High risk villages

Neither the total nor any age specific vaccination scar prevalence rate was significantly different for the residents of affected and unaffected villages. The accessibility of each village was measured by its proximity to a scheduled launch service and to a paved road, and by the means of travel required to reach the village during the wet and dry seasons. The proportion of villages into which smallpox was introduced was not significantly different for villages of varying degrees of accessibility, as measured by any of these variables, and affected villages were widely scattered throughout the study area.

The mean number of introductions per village can be seen in table 7 to increase with the population of the village. The size of villages was not found to be correlated with any of the indicators of accessibility, and no variation in vaccination scar prevalence with village size was noted.

The frequency with which smallpox was introduced into villages was not influenced by the presence of medical facilities, a post office, or schools; or by the proportion of inhabitants who were refugees or able to read block printing.

DISCUSSION

Clinical observation

This study corroborates several clinical observations made by others and by three of the authors on a larger series of cases seen during the acute stage of their illness in West Pakistan.[7] The unimodal distribution of fatalities by week of illness was similar to that observed in West Pakistan, and its implications have been discussed.[7] The reduced mortality among cases vaccinated prior to exposure has been well documented previously.[7-15] In both this and the West Pakistan study, almost no cases under five had been vaccinated. Yet, in both studies infants more frequently died than one to four year-olds, suggesting that factors other than specific acquired immunity also influence mortality, at least during the first year of life. The lower case fatality ratio among cases over five is probably due to the higher proportion of them that had been immunized.

The distribution of cases by duration of prodrome, was almost identical to that previously reported for variola major[7,10,16] and for variola minor.[17] No influence of prior vaccination on the duration of the prodrome was detected by either the present investigation or the study in West Pakistan,[7] and reports by others are conflicting or poorly documented.[8,18,19]

The scheme used in this investigation, to classify cases according to the density of their rash has two advantages for epidemiological studies over other classifications: (1) a knowledge of the clinical course of the illness is not required, and consequently each case can be classified on a single visit; (2) cases can be classified from the time their focal rash first appears until the depigmented scars resulting from lesions on their arms and face begin to fade. A similar classification was used in the West Pakistan investigation, and the unimodal distribution of unvaccinated cases by lesion density was almost identical in the two studies. Although the numbers are small, the apparent diminution of lesion density in previously immunized cases is consistent with that noted in the larger West Pakistan series.[7] Because no two classification schemes are directly comparable, the distribution of cases of variola major by clinical severity reported by other investigators[8,10,11,13,14,15,18,19,20] cannot be directly compared. However, most report a wide range of severity for cases of like vaccination status, and all report an attenuating effect of prior immunization on the density of rash.

The increase in attack rate with age for the previously vaccinated likely demonstrates the waning of acquired immunity with time.

High risk groups

As attack rates were ten-fold greater for unvaccinated than vaccinated individuals, those without vaccination scars constitute an obvious high risk group. Although most were under five, those from five to 14, particularly males, were at a greater risk of exposure. This was also noted in West Pakistan.[21] For individuals of each sex in three age groups from five to 19, attack rates were higher for those not attending school. Although the small numbers of cases precluded a determination of the statistical significances of this observation, it is consistent with observations made in the Punjab,[21] Tabriz,[22] and Karachi.[23] Hence, those not in school likely represent another group at relatively high risk. Thus, to most efficiently reduce the potential for smallpox transmission within rural Bengali villages, a high priority should be assigned to the vaccination of those not previously immunized, particularly five to 14 year-old males, and children not attending school.

No other priorities were identified. It has often been hypothesized[22,23] that the relatively lower status of women than men in Muslim cultures results in fewer females than males being vaccinated, and hence in more of them contracting smallpox. Neither this study nor the one in West Pakistan support this hypothesis. Although females in the present study area were slightly less well vaccinated than males, fewer developed smallpox. Conversely, although attack rates in the West Pakistan area were slightly higher for women than men, females were actually the better immunized sex.[21]

Only three of the 119 cases were Hindus, all others were Muslims, and the attack rate was considerably higher for adherents to the latter religion. However, two of the 24 introducers were Hindus, a number not significantly lower than expected from the distribution of the population by religion. No indigenous case resulted from one of the Hindu introducers; the other infected only one person. As shown in part 2,[1] over half of all outbreaks consisted of an introducer followed by either zero or one secondary case. Therefore, the apparently large difference in attack rates for the two religions was likely due to chance.

Temporal distribution of cases

Relatively large numbers of cases were reported in and near the present study area every six to eight years since 1930. A similar temporal pattern has been documented for all parts of the Indian sub-continent, and the relationship of this pattern to weather conditions has been investigated.[24]

Most cases occurred in the spring months. This seasonal variability in incidence is by no means an original observation. Bosunto is the Bengali word for both spring and smallpox. Rogers attempted to relate the seasonal rise in India[24] and in England and Wales[25] to periods of low absolute humidity. In support of Rogers' hypothesis, MacCallum and McDonald showed the maximal survival time of variola virus to be inversely related to relative humidity at 30°C,[26] and longer at lower than higher temperatures;[27] and epidemiological evidence from West Pakistan suggests that the seasonal variation is due to variation in the ambient survival time of the virus.[28] Reasons for the seasonal variation in Bengal nonetheless remain unclear. Although the incidence rise occurred prior to the annual monsoon rains, the spring in East Pakistan is hot and humid, conditions not conducive to long virus survival. The spring cluster of cases was preceded by an increase in the number of introductions into the area, but no data are available which suggest that this might have been due to an increase in travel frequency. On the contrary, no increase in travel into one Hindu and one Muslim village was observed during the spring of 1968.[29] No other possible determinants of the seasonal variation were investigated.

Introductions

There were no cases of smallpox in the study area from September through November. Furthermore, this study, like the one in West Pakistan,[30] has shown rural smallpox to be ultimately dependent on introductions from the outside. Three observations indicate that the number and distribution of susceptible people in the population did not provide the conditions necessary for the disease to be perpetuated in the area without these introductions; (1) as shown in part 2 of this report, the large majority of outbreaks consisted of but a few cases and were of short duration; and (2) factors other than vaccination efforts limited intravillage transmission. (3) Transmission of smallpox from one village to another within the study area was observed to be a rare event. Consequently, the prevention or early detection of introductions could serve as a convenient means by which smallpox could be eliminated from such rural populations.

To eliminate interlocality transmission, one could consider the following four approaches: (1) the identification of individuals transporting smallpox between localities, (2) selective vaccination of people most likely to become introducers, (3) eradication of smallpox from localities most likely to serve as foci of spread to other communities, and (4) vaccination of residents of localities into which smallpox is most likely to be introduced.

Over one-half of the introducers travelled during the asymptomatic incubation period of their disease. Surveillance for active cases at public transportation facilities would thus be of limited value, a conclusion also reached as a result of the study in West Pakistan.[30]

The majority of introducers were adult males, all were of landless families, and two-thirds were of families of unskilled or semi-skilled workers. All but one, however, were residents of the village into which they introduced smallpox. Such villages were widely scattered, and in both remote and easily accessible locations. Consequently, the selective vaccination of individuals most likely to become introducers would not constitute an efficient special programme. The assignment of a high priority to the vaccination of such individuals (as well as of members of high risk groups previously described), by those currently immunizing villagers of the area would, however, require no additional expenditures.

Over two-thirds of the introducers had travelled from cities with populations of more than 100 000 (Dacca or Narayanganj), usually because the family breadwinner had gone there for employment. Consequently the elimination of smallpox from such urban centres would also prevent a high proportion of the rural cases. As only 5 per cent. of the population of East Pakistan reside in cities these large, urban areas should be given the highest priority in any eradication programme. The results of the study in West Pakistan[30] also lead to this conclusion.

Smallpox was shown by this study, and by the one in West Pakistan[30] to be introduced into communities with a frequency directly related to the size of their populations. If this is also true for communities larger than those in the study area, then it can be concluded that mass vaccination campaigns should begin in the cities, and be conducted in other communities with a priority relative to their population size. This study provides no information by which the smallest community in which such a campaign should be conducted can be defined. However, if acquired immunity in the population were to be maintained at the present level, and if surveillance were to be improved so that introductions that do occur are rapidly detected and appropriate containment measures initiated, then it is hypothesized that eradication of smallpox could be accomplished without special mass vaccination campaigns in those rural areas to which the results of this study are applicable.

TABLE 1. DISTRIBUTION OF CASES BY VACCINATION SCAR STATUS AND AGE

Age	Scar		No scar		Unknown death		Unknown other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
< 1	0	0.0	3	6.1	7	24.1	0	0.0	10	8.4
1- 4	1	5.6	11	22.4	10	34.5	2	8.7	24	20.2
5- 9	3	16.7	24	49.0	6	20.7	5	21.7	38	31.9
10-19	4	22.2	7	14.3	3	10.3	3	13.0	17	14.2
≥ 20	10	55.6	4	8.2	3	10.3	13	56.5	30	25.2
Total	18	100.0	49	100.0	29	99.9	23	99.9	119	99.9

TABLE 2. DISTRIBUTION OF CASES BY VACCINATION SCAR STATUS AND YEARS SINCE PRIMARY VACCINATION

Years since primary vaccination	Scar		No scar		Unknown death		Unknown other		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	0.0	38	77.6	22	75.9	6	26.1	66	55.5
< 1	0	0.0	2	4.1	0	0.0	0	0.0	2	1.7
1- 3	1	5.6	2	4.1	0	0.0	0	0.0	3	2.5
3- 9	6	33.3	3	6.1	0	0.0	2	8.7	11	9.2
10-19	1	5.6	1	2.0	1	3.4	1	4.3	4	3.4
≥ 20	10	55.6	1	2.0	1	3.4	11	47.8	23	19.3
Unknown	0	0.0	2	4.1	5	17.2	3	13.0	10	8.4
Total	18	100.1	49	100.0	29	99.9	23	99.9	119	100.0

TABLE 3. AGE, SEX AND VACCINATION STATUS SPECIFIC CASE FATALITY RATIOS

	Variable	Cases	Deaths	Case fatality ratio
Age	< 1	10	7	70.0
	1- 4	24	10	41.7
	5- 9	38	6	15.8
	10-19	17	3	17.6
	≥ 20	30	3	10.0
Male		70	16	22.9
Female		49	13	26.5
Previously vaccinated		34	2	5.9
Unvaccinated		77	22	28.6
Unknown		8	5	-
Total		119	29	24.4

TABLE 4. AGE, SEX AND VACCINATION STATUS SPECIFIC SMALLPOX ATTACK RATES FOR THE STUDY AREA

Age	Previously vaccinated		Unvaccinated		Males		Females		Total	
	No. of cases	Rate per 10 000	No. of cases	Rate per 10 000	No. of cases	Rate per 10 000	No. of cases	Rate per 10 000	No. of cases	Rate per 10 000
< 5	1	1.5	31	24.2	14	14.2	20	20.4	34	17.3
5- 9	5	3.0	32	76.5	26	23.9	12	11.7	38	18.0
10-14	4	3.1	7	65.2	8	10.6	4	6.2	12	8.6
15-24	5	3.5	3	31.4	7	9.8	2	2.4	9	5.8
≥ 25	19	4.7	4	18.1	15	6.8	11	5.4	26	6.1
Total[a]	34	3.7	77	36.3	70	12.2	49	8.9	119	10.6

[a] Excluding eight unexamined cases with unknown vaccination history.

TABLE 5. DISTRIBUTION OF ALL CASES AND INTRODUCERS BY FAMILY OCCUPATION GROUP

Occupational group	Introducers		Others		Total	
	No.	%	No.	%	No.	%
Unskilled & semi-skilled	16	66.7	44	46.3	60	50.4
Skilled and merchants	8	33.3	22	23.2	30	25.2
Land owners	0	0.0	29	30.5	29	24.4
Total	24	100.0	95	100.0	119	100.0

TABLE 6. OBSERVED AND EXPECTED DISTRIBUTION OF OUTBREAKS OF KNOWN SOURCE BY POPULATION OF ORIGIN

Population of origin	Outbreaks			
	Observed		Expected[a]	
	No.	%	No.	%
< 100 000	7	31.8	20.9	95
≥ 100 000	15	68.2	1.1	5
Total	22	100.0	22.0	100

[a] Expected number of outbreaks calculated from percentage distribution of East Pakistan population by size of community of residence.

TABLE 7. NUMBER OF INTRODUCTIONS PER VILLAGE BY POPULATION OF VILLAGE

Village population	No. of introductions[a]	No. of villages	Introductions per village
< 500	7	51	0.14
500- 999	10	47	0.21
1000-1999	6	24	0.25
≥ 2000	7	10	0.70
Total	30	132	0.23

[a] Two outbreaks resulting from two introducers travelling together considered the result of a single introduction.

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Figure 1. Per Cent of Examined Males and Females in the Study Area Without Vaccination Scars by Age

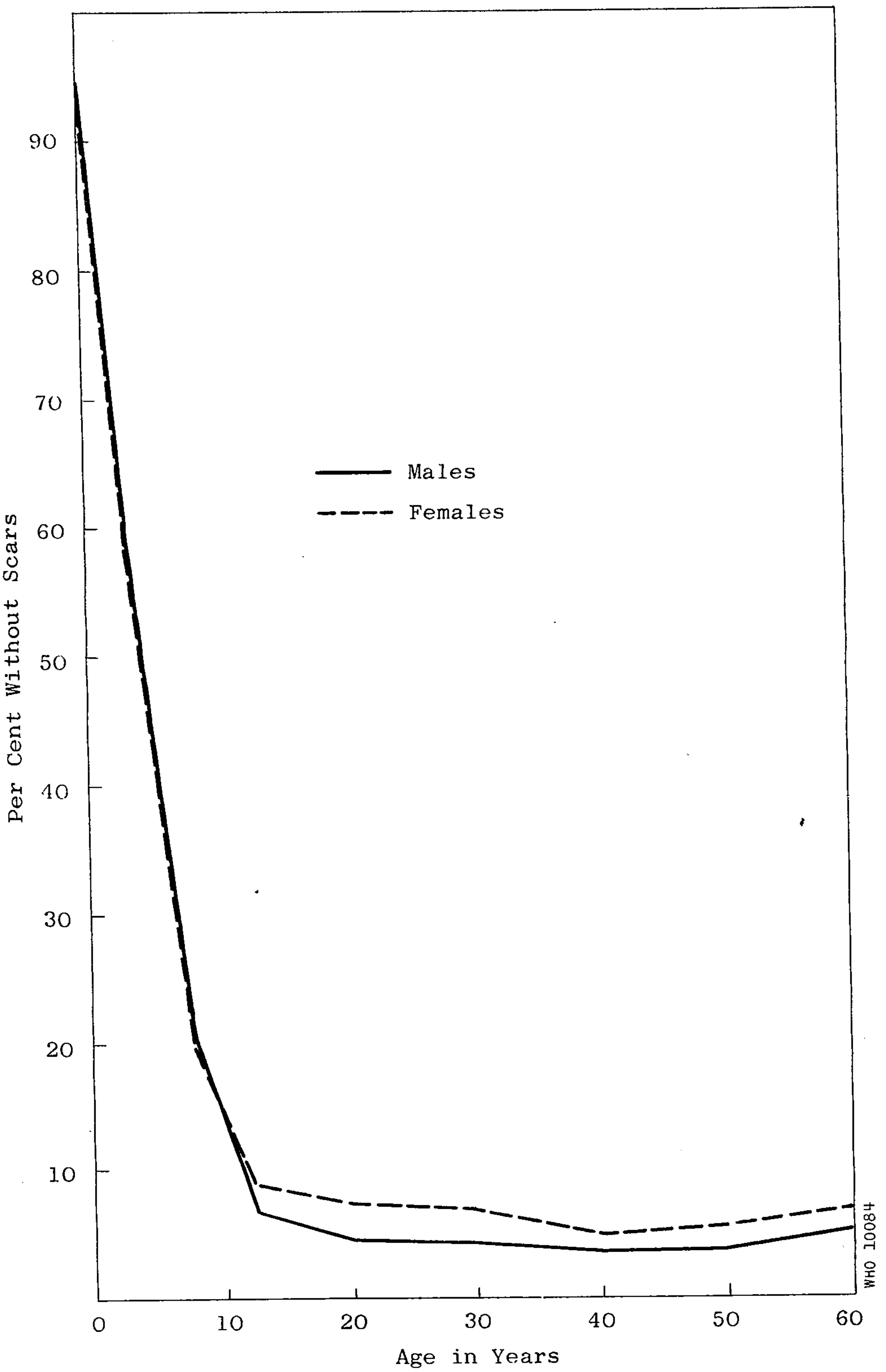

Figure 2. Number of Cases Occurring During Each 2-Week Period from July 1, 1966 to June 30, 1967

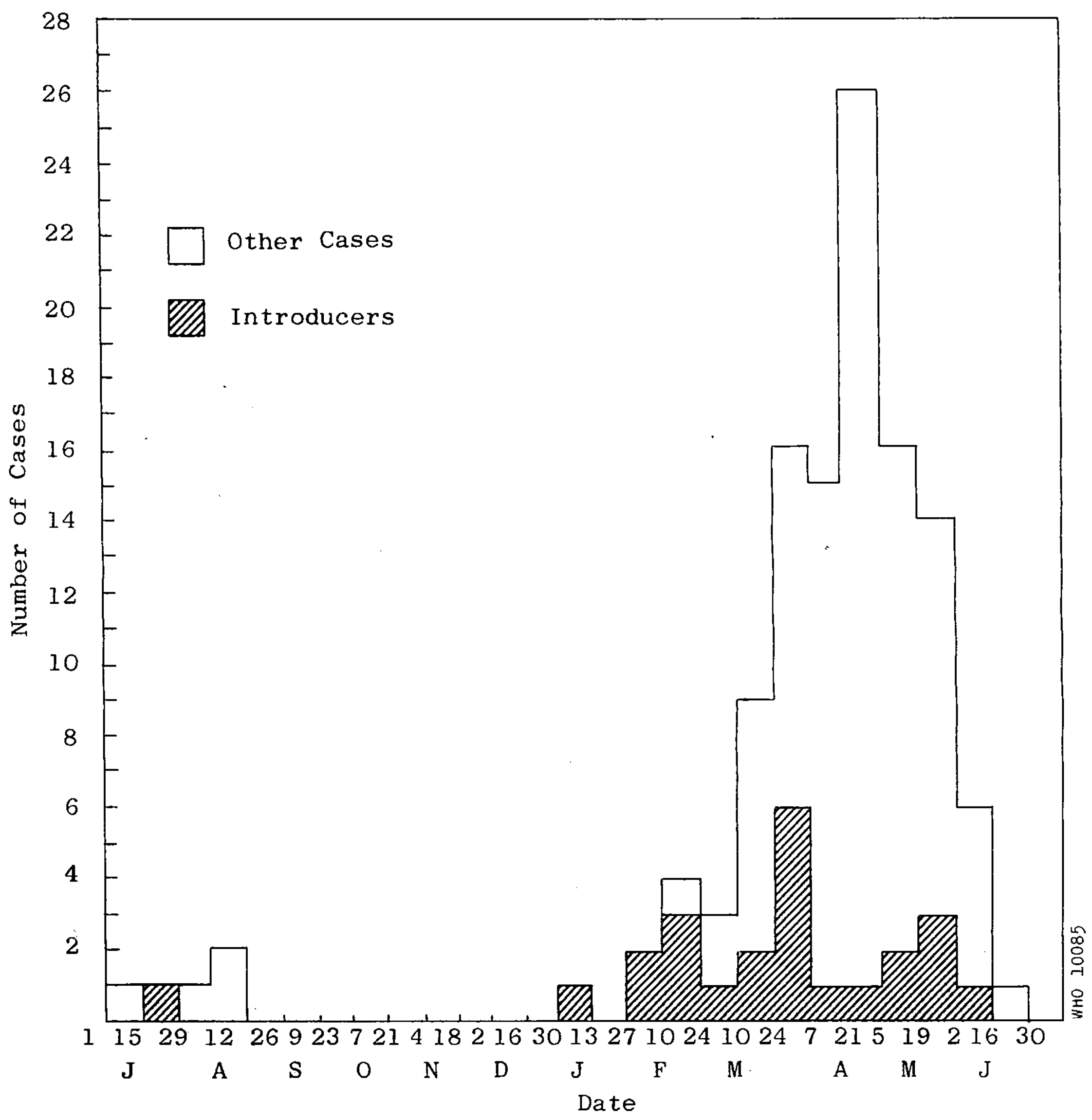

Figure 3. Age and Sex Specific Attack Rates