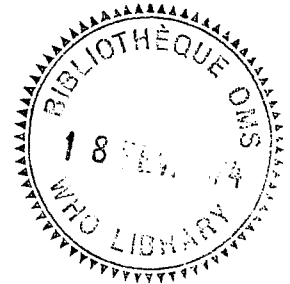




SMALLPOX EPIDEMIC IN A BRAZILIAN COMMUNITY¹

by

Eduardo de Azeredo Costa, M.D., D.T.P.H. (London)²
Leo Morris, M.P.H.³



SUMMARY

The most severe outbreak of smallpox in Brazil in 1969 took place in the município of Utinga, Bahia. Of 507 cases, 246 occurred in residents of the urban area of the município. This paper describes the findings of the detailed study of the urban area outbreak. An inverse relationship between age and susceptibility was evident; fully 91% of the children less than five years of age as well as 75% of the school-age children had no history of smallpox and had never been vaccinated. The overall attack rate was 11% with nearly three-fourths of the cases in children under 15 years of age. Only four of the 246 patients had a vaccination scar, and the estimate of vaccine efficacy was 94%. The continued occurrence of cases after the initial vaccination containment measures prompted detailed studies during two follow-up visits to the community which demonstrated that (1) transmission of smallpox may continue in a pocket of susceptibles although the overall immune status of a community is high following containment measures, and (2) clinical illness may have been aborted in those affected individuals who were only in their second to fourth day of incubation at the time of vaccination.

¹ From the Smallpox Eradication Programme (Campanha de Erradicação da Varíola - CEV), Ministry of Health, Rio de Janeiro, Brazil.

² Formerly Medical Epidemiologist, Fundação SESP, Ministry of Health, on assignment to CEV; present address: Dept. de Epidemiologia, Inst. Pres. Castello Branco (Formerly Escola Nacional de Saúde Pública), Caixa Postal 8016, Rio de Janeiro-GB, Brasil.

³ Formerly Pan American Health Organization Statistical Consultant to CEV; present address: Bureau of Epidemiology, Center for Disease Control, U.S. Public Health Service, Atlanta, Georgia 30333.

INTRODUCTION

The Brazilian Smallpox Eradication Programme - Campanha de Erradicação da Varíola (CEV) - was created in 1966 and given the technical and operational responsibility for eradicating smallpox in Brazil.¹ Field training and organization of the systematic vaccination programme were the principal activities of CEV through mid-1968. At that time, increasingly greater emphasis was put on surveillance activities and epidemic investigation. In early 1969, smallpox surveillance units were established in the states of Bahia, Minas, Gerais, and Paraná. Their responsibilities included investigation of reported cases, outbreak control, and development and extension of the reporting network.²

Largely as a result of the smallpox surveillance unit activities in Bahia, 2140 cases of smallpox were reported in that state in 1969. This compares with an annual average of only 196 cases for the previous five-year period (1964-1968). Nearly one-fourth of the total number of cases, 507, occurred in the município (county) of Utinga, representing the most severe outbreak in Brazil in 1969. Of the 507 cases, 272 occurred in the urban area of the município. This paper describes the findings of the detailed study of the urban area outbreak.

BACKGROUND

The município of Utinga is 350 kilometers west of Salvador, the capital of Bahia, in the semi-arid interior ("sertão") of the state. The estimated population (1968) was 9277 with a population density of 7.6 persons per square kilometer. Principal crops in the area are tobacco, castor oil, beans, manioc, and cotton. The City of Utinga is the only urban area in the município and has an estimated population of 2200. The weekly market in the city draws residents of the rural area of Utinga and surrounding municípios.

During the week ending 2 August, the surveillance unit received a report of one case of smallpox from the município of Bom Jesus da Lapa, which lies 300 kilometers southwest of Utinga on the São Francisco River. The patient was a resident of Fazenda Alto Bonito, a rural locality in the município of Utinga, and was already ill when she arrived in Bom Jesus da Lapa. On that same day, the surveillance-containment team went to Utinga, where they found that an epidemic had been in progress since February. Despite the fact that over 300 cases had occurred before August, the outbreak had never been reported.

During the first visit to Utinga (1-2 August), the team recorded smallpox cases in 13 rural localities in addition to Utinga City. The surveillance-containment team vaccinated the residents of the 13 rural localities, 415 persons attending the weekly market in Utinga City, and 1020 contacts of the 206 persons who had contracted smallpox in the city up to 2 August.

The team visited Utinga City again on 22 August and 27 September to verify the effectiveness of the containment operations, as well as to record the information included in this study.

METHODS

To determine the extent of the outbreak in Utinga City, investigators visited every household and for each of the 104 households with one or more cases of smallpox completed an epidemiologic case record form. This form includes space for such information as age, sex, residence, date of onset of illness, history of previous smallpox illness (prior to February 1969), and vaccination history, including examination for the absence or presence of a vaccination scar. In addition, the age, sex, vaccination status and smallpox history of all non-ill household contacts was recorded.

To identify those individuals with a previous smallpox illness, a history of smallpox rather than residual smallpox scarring was recorded, since only a small proportion of those who have had variola minor show persistent facial scars compared with those who have had variola major.^{3,4,5} Epidemiologic data, as well as laboratory studies, indicate that variola minor has been the only form of smallpox present in Brazil in recent years.^{1,2,6,7,8}

A "vaccinated person" is defined as one who has been successfully vaccinated, i.e., has a vaccination scar as evidence of successful vaccination. As in this outbreak, surveillance data in Brazil have shown that variola minor rarely occurs in successfully vaccinated individuals.^{1,2} Therefore, residents of affected households with no previous history of smallpox or successful vaccination have been classified as "susceptibles".

RESULTS

Epidemic curve

During the first week of February, a family of ten moved from the rural district of Duas Barras in the neighbouring município of Morro do Chapéu to Utinga City. The parents and five of the children, all over age ten, stated that they had experienced smallpox in 1960. The three other children, born after 1960, had neither been vaccinated nor exposed to smallpox (prior to 1969). On 14 February, one of these children had onset of smallpox; her two susceptible siblings had onset on 28 February and 15 March, respectively. Playmates in two neighbouring households became ill on 26 February and 11 March, respectively. Smallpox slowly spread through the community, reaching peak incidence during the middle weeks of July (Fig. 1).

Subsequent investigation in the rural district of Duas Barras confirmed a smallpox outbreak that had begun in November 1968 and terminated spontaneously in May 1969. During that period, 154 of 505 residents (30.5%) had contracted smallpox. The source could not be determined.⁹

In Utinga City, 272 cases of smallpox were recorded; 26 were in non-residents. The 246 patients who were residents of the city resided in 104 households scattered throughout the community. There was only one death. The case-fatality rate of 0.4% is indicative of variola minor.

Smallpox virus was identified by the Virus Laboratory of the National School of Public Health in Rio de Janeiro.¹⁰

Past smallpox and immunity in the households affected

In the 104 affected households there were 618 residents (Table 1). Of these, 151 have a history of a previous smallpox illness (24%). The proportion of individuals with previous smallpox increased with age, and half of those 30 years of age and over had already suffered smallpox. No child under five years of age had a history of smallpox, reflecting the absence of smallpox in Utinga for at least a five-year period.

One hundred and thirteen of the 618 residents had vaccination scars (18%). This excludes three persons with both a history of smallpox and a vaccination scar who have already been included among the 151 persons with a previous smallpox illness. They have been excluded here, so the categories may be mutually exclusive. The remaining 57% of the household residents had neither a history of smallpox nor a vaccination scar. The proportion in each age group with no history of smallpox and no vaccination scar progressively decreased with age. Fully 91% of the children less than five years of age as well as 75% of the school-age children (5-14 years) were susceptible at the beginning of the outbreak.

Smallpox attack rates

There were 246 cases of smallpox in Utinga residents for an overall attack rate of 11%. Nearly three-fourths of the cases were in children under 15 years of age. Only 6% were in adults 30 years of age or older (Table 2). There was no significant difference in cases by sex.

The total attack rate for the 618 residents in the affected households was 39.8%. Only four of the 246 patients had a vaccination scar (Table 3). The dates of vaccination were 1938, 1947, 1965 and 1967, respectively. The last two had mild cases with few lesions. The attack rate for the 113 vaccinated individuals was 3.5%.

Sixty-eight per cent. of 354 residents with no vaccination scar contracted smallpox - an attack rate 20 times higher than for vaccinated persons. The total attack rate decreases after 15 years of age, reflecting the higher immunity status of the population in the older age groups. However, no decrease is seen in the attack rate for those without a vaccination scar until 30 years of age.

An estimate of the efficacy of smallpox vaccine in preventing variola minor in an epidemic was calculated. Attack rates for the unvaccinated were used to obtain an expected number of cases in each age group among the vaccinated population. The total number of expected cases, 69, was then compared with the observed number of four cases. The reduction in expected cases among the vaccinated, or age-adjusted vaccine effectiveness ratio, was 94%.

Nearly two-thirds of the affected households had either one or two cases (Table 4). One household had as many as eight cases. The average household size was 5.9 persons.

Smallpox before and after control measures

In May, local health officials vaccinated nearly 500 individuals, of whom only three experienced major reactions indicative of successful vaccination. Obviously, the vaccine did not have satisfactory potency. Even though the number of cases continued to increase through June and early July (Figure 2), the existence of the epidemic was not reported. In fact, as previously noted, the surveillance team discovered the outbreak only through the investigation of a case in a Utinga resident who had become ill in another city.

On the first visit to Utinga, the team vaccinated 1020 households and other contacts of the 186 cases occurring in 78 households through 2 August. However, cases could be then expected to occur for another two weeks, since some vaccinees were undoubtedly in their incubation period following known intimate contact with patients. Therefore, the team made a second visit three weeks later to determine the effectiveness of the containment measures.

During this second visit on 22 August, 31 additional cases in 19 households, all with onsets after 2 August, were discovered. Eighteen of the 31 cases occurred in 12 households not previously affected, and the remaining 13 cases were in households with smallpox on or prior to 2 August. Twelve of the 31 patients had been vaccinated on either 1 or 2 August, but 19 had never been vaccinated. The 12 vaccinated patients, all primary vaccinees, had onset of rash between 5 and 12 August, indicating that they were already in their incubation period at the time of vaccination. The longest interval between primary vaccination and onset of symptoms (rash) was ten days (Table 5). Further investigation revealed that many susceptibles had not been vaccinated on the first visit because they were either in the fields for periods of "several days up to a week", had refused vaccination, or had been just plain missed by the containment team. Generally, the field workers, sometimes including the entire family, will stay in the fields during the week and return to the city for the weekend. However, during the planting season, they will stay in the fields as long as necessary. On this visit, another 912 persons were vaccinated, and by 22 August, over 1900 persons in a city with 2200 residents had been vaccinated or revaccinated.

On the third visit to Utinga on 27 September, the team identified 29 additional cases, including 15 that occurred more than two weeks after the second vaccination programme, indicating that transmission had not yet been completely interrupted. All but one were unvaccinated, and some susceptible contacts that had not yet been vaccinated were still found during this third visit to Utinga. An additional 288 persons were vaccinated, and only two more cases occurred after 27 September (Fig. 3).

DISCUSSION

Once smallpox was introduced into Utinga, the subsequent epidemic could well have been expected, since there had been no cases in the community for at least five years, and the overall immunity status was low. Fifty-seven per cent. of the persons in affected households had no history of smallpox and no vaccination scar and were considered susceptible. Fully 80% of the 317 children less than 15 years of age had neither a history of smallpox nor a vaccination scar. Nearly three-fourths of the cases occurred in this age group.

The attack rate for susceptible individuals in households with one or more cases varied between 61% and 76% for all age groups through 29 years of age. For those 30 years of age and older, the attack rate was only 44%. The fact that fewer apparently susceptible contacts in this older age group contracted smallpox, despite intimate household contact, suggests that some of the older individuals had as children had a mild and forgotten or misdiagnosed case of smallpox. This would falsely inflate the number of susceptibles at risk, resulting in an attack rate that was artificially low.

Only four cases occurred in individuals who had been successfully vaccinated prior to the outbreak, and the estimate of vaccine efficacy was 94%. This high effectiveness ratio agrees with other effectiveness ratios calculated from surveillance data in Brazil.^{1,2} In contrast to the substantial protection afforded by vaccine, two-thirds of those with no vaccination scar in affected households contracted smallpox.

The epidemic in Utinga City appears to have passed its peak prior to the initial containment measures on 1 and 2 August. However, these measures probably contributed to a more rapid decline in cases following the epidemic peak, even though it became apparent that a substantial number of susceptible contacts had been missed during the initial containment measures. Smallpox had occurred or continued to occur in 32 households after the containment procedures on 1 and 2 August. In these households, three-fourths of those never vaccinated contracted smallpox with onset of disease after 2 August (Table 6). Of the 46 residents vaccinated on 1 or 2 August for the first time, 12 became ill, all between 5 and 12 August as previously indicated, for an attack rate of 26.1%.

Since immunity conferred by primary vaccination does not begin to develop until the tenth day post vaccination,¹¹ one would expect no decline in cases post vaccination for about ten days, following which a sharp decline in cases should occur. In Utinga, one to three cases occurred daily post vaccination until the tenth day; all were in primary vaccinees (Table 5). No other individual who had been vaccinated on 1 or 2 August developed smallpox. Thus, protection appears to have been complete 11 days after primary vaccination, correlating well with laboratory studies dealing with antibody response following primary vaccination. Given the usual 12-14 day incubation period for smallpox, the Utinga experience suggests that clinical illness may have been aborted in those infected individuals who were only in their second to fourth day of incubation at the time of vaccination.

If containment vaccination had been 100% complete, no additional cases would be expected more than 11 days (i.e. 12 August) after the vaccination of all of the household and other contacts of cases on 1-2 August. An examination of the characteristics of cases occurring after 12 August is thus of interest in attempting to identify the nature of the failure in the control operation. The age and sex distribution of cases with onset on or before 12 August and of those with onset after that date are compared in Table 7. There is a greater proportion of cases (37.1%) among adults (15 years of age and older) in the later

period than in the earlier period (24.6%). However, this difference is not statistically significant (Yates corrected chi-square = 1.81). There is also a greater proportion (40.0%) of young children (0-4 years of age) afflicted during the later period than in the earlier (20.4%). Although young children are more likely than children 5-14 years of age to be carried into the fields with their parents and thus miss vaccination in the city, it has also been documented in Brazil that children under five years of age within a household are more likely to be secondary cases which thus occur later in an epidemic.^{2,12} There is no difference in the distribution of cases by sex during the two time periods.

Up to 12 August, 211 cases had occurred in 96 households. Of the 35 cases with onset on or after 13 August, only seven were in households already infected as of 2 August. Thus complete vaccination of contacts on 2 August in only the affected households would have prevented, at best, only one-fifth of the cases that subsequently occurred.

In the 32 households where cases occurred or continued to occur after the initial containment vaccination programme, 63 of the 109 residents who had no vaccination scar and had never suffered smallpox had escaped vaccination (Table 6). Thus, in these households, there existed pockets of poorly protected individuals although the overall immune status of the city was known to be high. Twelve of the 46 susceptible individuals (26%) in these households who were vaccinated on 1 and 2 August subsequently had onset of smallpox, all within ten days, indicating that they were already in their incubation period at the time of vaccination. Assuming that the 63 susceptibles who were not vaccinated had equal exposure to the index case in their respective households, 16 (26%) of them would be expected to have become ill even if vaccinated on 1 and 2 August. If containment measures had been more rigorous during the first visit to the city, up to 31 of the 47 cases that occurred in this group might have been prevented.

Thompson & Foege have described an outbreak of smallpox in a pocket of poorly protected people in an otherwise well protected urban population.¹³ Transmission of smallpox occurred in a city where the overall immunity status of the population was known to be high but there remained a small group of susceptibles who associated together because of their religious background. In Utinga, transmission continued to occur within a well-vaccinated community among pockets of susceptibles which included three distinct groups: (1) persons working in the fields who missed vaccination, (2) persons in households that refused vaccination, and (3) households missed during the containment vaccination programme for one reason or another.

Knowing that a high percentage of a community is well protected by vaccination should not be the basis for assuming that transmission will not occur or continue to occur. One must be assured that there are no unprotected groups or pockets existing as "islands" within the overall well protected community. Also, a community such as Utinga may be administratively classified as an urban area because it is the county seat, but it is obviously more of an "agrovila" which serves the surrounding rural area. The characteristics of the inhabitants are more rural than urban, and the surrounding rural area must be treated as epidemiologically related to the community itself.

Following containment procedures in any outbreak, it is clear that a repeat visit is necessary, two to three weeks later, to identify those cases in persons vaccinated during their incubation period and to verify the completeness of the control procedures.

REFERENCES

1. Suzart, E., et al. (December 1970) Smallpox eradication in Brazil, 1967-69, Bull. Wld Hlth Org., 43, 797-808
2. Quadros, C. A., et al. (1972) Epidemiology of variola minor in Brazil based on a study of 33 outbreaks, Bull. Wld Hlth Org., 46, 165-171
3. Mack, T. M., Thomas, D. B. & Khan, M. M. (December 1970) Variola major in West Pakistan, J. Inf. Dis., 122 (6), 479-488
4. Foster, S. O., Persistence of facial scars of smallpox in West African populations, Unpublished paper, Smallpox Eradication Programme, Center for Disease Control, Atlanta, Georgia
5. Henderson, D. A., Personal communication, Smallpox Eradication Unit, WHO, Geneva
6. Briceno Rossi, A. L. (1963) Las Diferencias del Virus de Alastrim, Bol. Offic. Sanit. Panamer., 24, 419-423
7. Downie, A. W., et al. (1963) Alastrim in Brazil, Trop. Geogr. Med., 15, 25-28
8. Noble, J. & Salles-Gnomes, L. F. (September 1968) A laboratory study of Brazilian smallpox, Seminar on the Laboratory Diagnosis of Smallpox in the Americas, Instituto Oswaldo Cruz, Rio de Janeiro
9. Ministerio da Saúde (13 de dezembro de 1969) Boletim Semanal da Campanha de Erradicação da Varfola, 3 (38), 1-3 (Rio de Janeiro, Brazil)
10. Azeredo Costa, E., et al. (1972) Serological studies on an outbreak of smallpox in the State of Bahia, Brazil in 1969, Mem. Inst. Oswaldo Cruz, 70 (3), 285-297
11. McCarthy, K., Downie, A. W. & Bradley, W. H. (1958) The antibody response in man following infection with viruses of the pox group. II. Antibody response following vaccination, J. Hyg. (London), 56, 466-478
12. Arnt, N. & Morris, L. (April 1972) Smallpox outbreaks in two Brazilian villages - epidemiologic characteristics, Amer. J. Epid., 95, 363-370
13. Thompson, D. & Foege, W., Faith tabernacle smallpox epidemic in Abakaliki, Nigeria, Unpublished paper, Smallpox Eradication Programme, Center for Disease Control, Atlanta, Georgia

TABLE 1
IMMUNITY STATUS BY AGE GROUP
IN 104 HOUSEHOLDS WITH ONE OR MORE
CASES OF SMALLPOX, UTINGA-BRAZIL

AGE GROUP	TOTAL RESIDENTS	SMALLPOX HISTORY	VACCINATION SCAR		PERCENT SUSCEPTIBLE*
			YES	NO	
0-4	103	0	9	94	91.3
5-14	214	21	32	161	75.2
15-29	148	55	26	67	45.3
30+	<u>153</u>	<u>75</u>	<u>46</u>	<u>32</u>	<u>20.9</u>
TOTAL	618	151	113	354	57.3

*Those individuals with neither a vaccination scar nor history of smallpox as of February 1, 1969.

TABLE 2. SMALLPOX CASES BY AGE AND SEX
UTINGA CITY, BRAZIL, 1969

Age group	Number of cases			Percent of total
	Male	Female	Total	
<1	2	7	9	3.7
1-4	24	24	48	19.5
5-14	65	59	124	50.4
15-29	22	28	50	20.3
30-44	3	6	9	3.7
45+	3	3	6	2.4
Total	<u>119</u>	<u>127</u>	<u>246</u>	<u>100.0</u>

TABLE 3. SMALLPOX CASES AND ATTACK RATES BY AGE-GROUP AND IMMUNITY STATUS IN 104 AFFECTED HOUSEHOLDS, UTINGA, BRAZIL

Age group	Number of cases				Attack rate (%)			
	Total	Smallpox history	Vaccination scar		Total	Smallpox history	Vaccination scar	
			Yes	No			Yes	No
0-4	57	0	0	57	55.3	0.0	0.0	60.6
5-14	124	0	1	123	57.9	0.0	3.1	76.4
15-29	50	0	2	48	33.8	0.0	7.7	71.6
30+	<u>15</u>	<u>0</u>	<u>1</u>	<u>14</u>	<u>9.8</u>	<u>0.0</u>	<u>2.2</u>	<u>43.8</u>
Total	<u>246</u>	<u>0</u>	<u>4</u>	<u>242</u>	<u>39.8</u>	<u>0.0</u>	<u>3.5</u>	<u>68.4</u>

TABLE 4

DISTRIBUTION OF CASES BY
NUMBER OF CASES PER AFFECTED HOUSEHOLD¹

NUMBER OF CASES PER HOUSEHOLD ²	AFFECTED HOUSEHOLDS	
	NUMBER	PERCENT OF TOTAL
1	43	41.4
2	25	24.0
3	16	15.4
4	6	5.8
5	7	6.7
6	4	3.8
7	2	1.9
8	<u>1</u>	<u>1.0</u>
TOTAL	104	100.0

¹Average household size 5.9
²Average N° of cases per household 2.5

TABLE 5
SMALLPOX CASES WITH
DATE OF ONSET POST-VACCINATION
UTINGA, BRAZIL

INTERVAL BETWEEN PRIMARY VACCINATION AND ONSET OF RASH (DAYS)	NUMBER OF CASES
1	0
2	0
3	1
4	2
5	3
6	2
7	2
8	1
9	0
10	1
11+	0

TABLE 6
SMALLPOX CASES IN 32 HOUSEHOLDS
AFTER FIRST VACCINATION PROGRAM
BY IMMUNITY STATUS

<u>IMMUNITY STATUS</u>	NUMBER OF RESIDENTS	SMALLPOX CASES WITH ONSET AFTER AUGUST 2	ATTACK RATE (%)
Smallpox prior to 1969	44	0	0.0
Smallpox in 1969 before August 2	11	0	0.0
Vaccination scar before August 2	14	1	7.1
Vaccinated on August 1 or 2	46	12	26.1
Never vaccinated	<u>63</u>	<u>47</u>	74.6
TOTAL	178	60	

TABLE 7
SMALLPOX CASES BY DATE OF ONSET,
AGE GROUP AND SEX
UTINGA CITY, BRAZIL - 1969

A. <u>CASES WITH ONSET ON OR BEFORE AUGUST 12:</u>				
AGE GROUP	MALE	FEMALE	TOTAL	PERCENT OF TOTAL
0- 4	20	23	43	20.4
5-14	61	55	116	55.0
15-29	17	25	42	19.9
30+	5	5	10	4.7
TOTAL	103	108	211	100.0
B. <u>CASES WITH ONSET AFTER AUGUST 12:</u>				
AGE GROUP	MALE	FEMALE	TOTAL	PERCENT OF TOTAL
0- 4	6	8	14	40.0
5-14	4	4	8	22.9
15-29	5	3	8	22.9
30+	1	4	5	14.2
TOTAL	16	19	35	100.0

FIGURE 1
SMALLPOX CASES BY MONTH OF ONSET
UTINGA CITY, BRAZIL - 1969

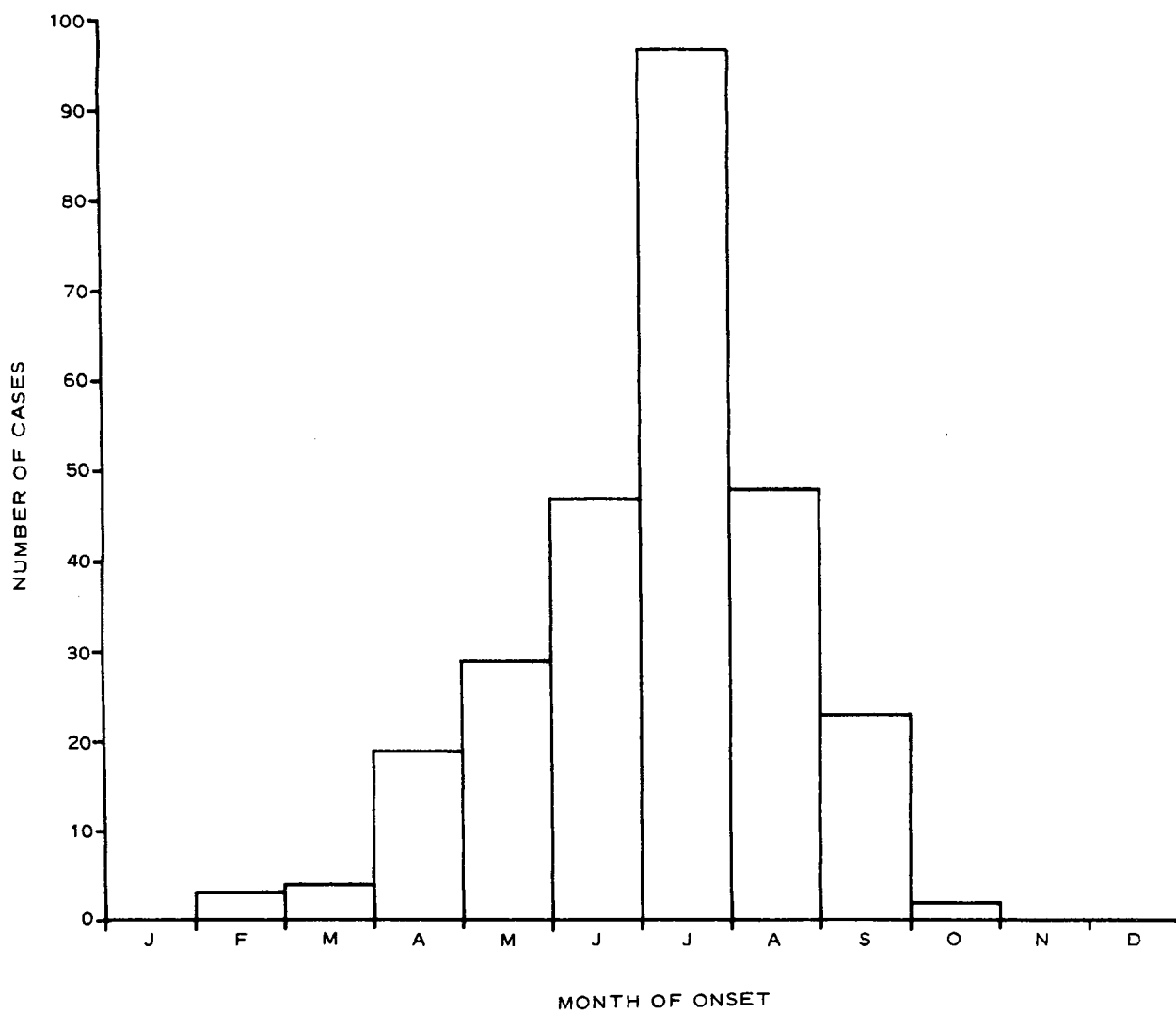


FIGURE 2
SMALLPOX CASES BY DATE OF ONSET
UTINGA CITY, BRAZIL - MAY 11-OCTOBER 25, 1969

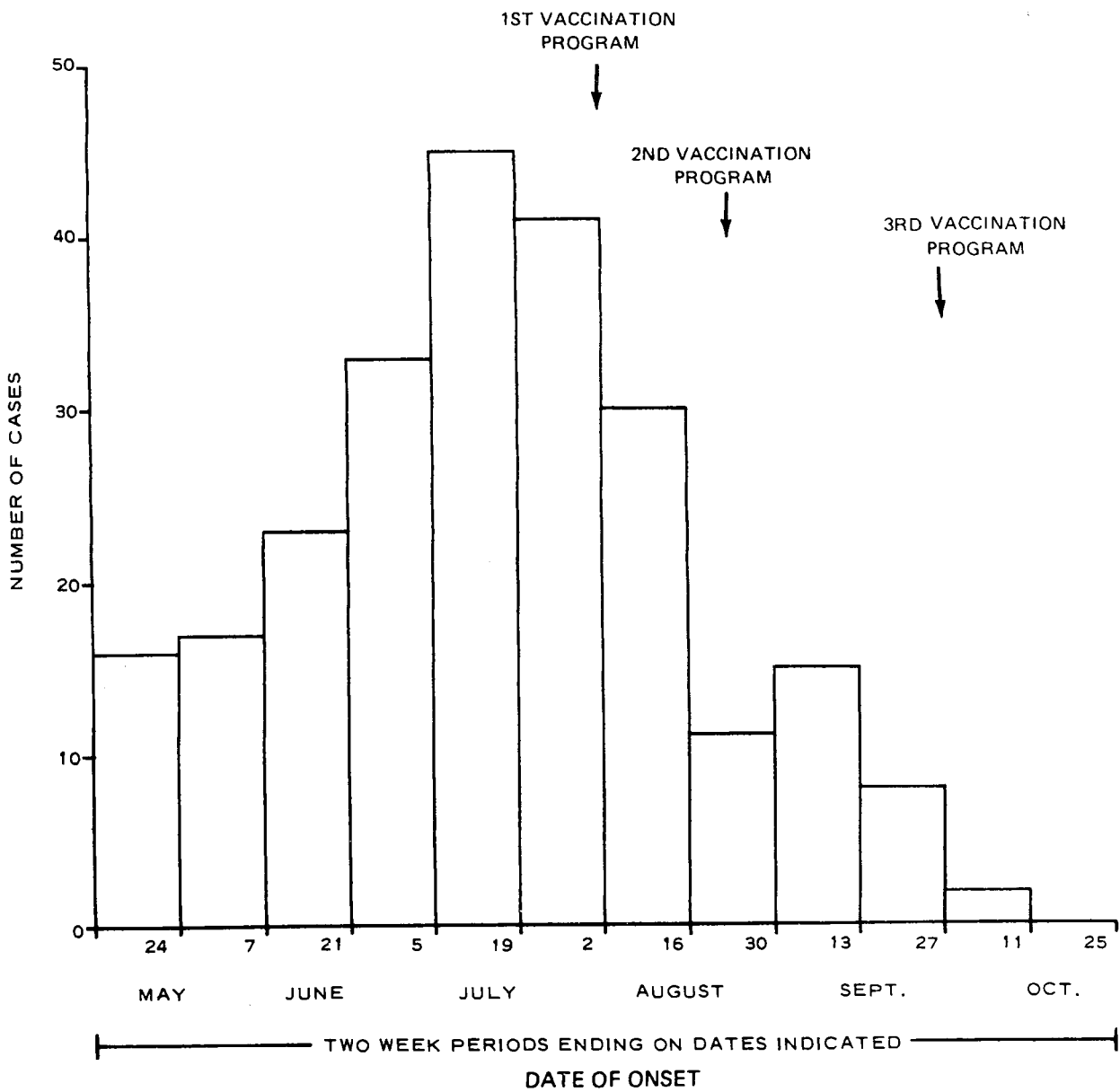


FIGURE 3
SMALLPOX CASES BY WEEK OF ONSET
AFTER FIRST VACCINATION PROGRAM
UTINGA CITY, BRAZIL
AUGUST 3-OCTOBER 25, 1969

