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**STUDIES OF  
SMALLPOX VACCINATION  
BY JET INJECTION IN BRAZIL**

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## STUDIES OF SMALLPOX VACCINATION BY JET INJECTION IN BRAZIL

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## STUDIES OF SMALLPOX VACCINATION BY JET INJECTION IN BRAZIL\*

Since World War II, jet injection has become well-accepted as a means of administering a number of immunizing agents. Batson<sup>1</sup> and others first used jet injector apparatus for vaccine administration (typhoid) and, subsequently, others have used it for poliomyelitis, yellow fever, influenza vaccines, and other antigenic agents.<sup>2-4</sup>

Work with smallpox vaccination was delayed because the equipment previously available was designed to deliver the materials subcutaneously. Ellisberg<sup>5</sup> and his associates using the then available jet injector equipment performed smallpox vaccinations in 1955 and reported it to be a successful technique, as measured by both clinical and serologic means. They used a 0.5 cc. dose of inoculum containing  $10^5$  CAM units of smallpox vaccine produced in egg membranes. They postulated that the success observed was due to that amount of virus which was trapped in the superficial skin layers as the jet stream passed through.

Recently Meyer<sup>6</sup> and associates used the standard military jet injector (automatic hypodermic jet injector device, Scientific Instrument Manufacturing Company, Larchmont, New York) slightly modified by the addition of a small plastic cap to raise the instrument from the skin and permit more of the injected material to remain in the superficial layers. They reported success as measured serologically in the administration of smallpox vaccine alone and in combination with yellow fever and measles vaccines.

In the spring of 1962, Ismach and associates at the Medical Equipment Research & Development Laboratory, U.S. Army, introduced a nozzle for

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use on the standard military model jet injector designed specifically for use in intradermal injections. The nozzle has a depressed center surrounding the injector tip into which the skin folds to receive an angulated injection. Subsequently, the Scherer Company has marketed an intradermal nozzle utilizing the same principle for use on their equipment.

The studies described here have been primarily an assessment of the military nozzle.

#### 1. Previous Studies Performed by CDC

Between winter 1963 and spring 1964, four studies were completed prior to the initiation of the Brazilian studies. These were designed to assess the feasibility of performing successful smallpox vaccinations by jet injection, as measured both clinically and serologically, and an attempt to define the appropriate dilution of the vaccine optimal for performing primary vaccinations and revaccinations. A part of these earlier studies has been published.<sup>7</sup>

In all these studies, there are certain similarities in methodology; nevertheless each individual study was conducted for somewhat different reasons and, therefore, involve somewhat different methodologic approaches.

In all the studies prior to Brazil, U.S. lyophilized vaccine (Dryvax - Wyeth) was exclusively used. Dilutions of vaccines have been prepared as follows: To a 0.3 cc. fill of lyophilized vaccine, an indicated number of milliliters of Hanks solution (first study only) or physiologic saline was added. Thus, the 1:10 dilution was prepared by diluting a 0.3 cc. dried fill in 10 cc. of saline (or Hanks solution); 1:50 dilution, a 0.3 cc. fill in 50 cc., etc. The standard 0.3 cc. fill contains 10 multiple pressure doses and the jet injector dose is 0.1 cc. of the diluted vaccine, so that

at the 1:10 dilution each multiple pressure dose of vaccine renders 10 jet injection doses; at the 1:50 dilution each one multiple pressure dose yields 50 jet injection doses. The dilution designated is thus not a volumetric one but descriptive of the difference in virus titer of a single dose. Titers of the undiluted vaccine and estimates of the amounts of virus injected with a single dose of each prepared dilution appear in Table I. Injections of a 0.1 cc. dose were made into the deltoid area.

The multiple pressure vaccinations in controls were performed with undiluted vaccine reconstituted in the diluent provided commercially. The technique consists of 30 tangential pressures through a drop of the vaccine placed on the skin.

Surveillance and evaluation of the results of vaccination were accomplished in the first study by daily clinical examination and photography of the lesions for 14 days after vaccination; the second and third studies by evaluations on the 2nd, 4th, 7th, and 14th days after vaccination; and in the large-scale Tonga study by a single reading on the 12th-16th day. Readings included the measure of erythema or induration at the site of vaccination, and a recording of the presence or absence of vesicle or pustule formation. Interpretation of readings of primary vaccinations presented no problem in that the development of a typical Jennerian primary reaction was considered as a satisfactory response. With revaccines, however, considerable difficulty is encountered in interpretation of results following vaccination. Previous work has drawn attention to the needs for differentiating the allergic response immediately following vaccinations from actual evidence of viral multiplication and has led to the present use by the World Health Organization of the terms "major" and "equivocal" reactions. A successful revaccination (major reaction) is defined<sup>8</sup> as "one

which on examination one week (6-8 days) later shows a vesicular or pustular lesion or an area of definite palpable induration or congestion surrounding a central lesion, which may be a scab or ulcer." Anything less than this is adjudged an equivocal reaction.

Thus, for comparison of reactions in revaccinees, the day 7 reading was selected as the critical one and further arbitrarily established the criteria of measurable erythema or induration of an area of 1 cm.<sup>2</sup> or more (diameter x diameter) as the minimum acceptable amount of erythema or induration. This was then considered together with evidence of vesiculation as the parameters of skin response.

In the first and third studies, sera were drawn on the day of vaccination and 28 days after vaccination from all participants and titers of neutralizing and/or hemagglutination inhibition antibodies in these sera were determined. Neutralizing antibody determinations were made by the 50% plaque reduction technique in Rhesus monkey kidney tissue cultures. In the Jamaican and Tongan studies, subjects were sampled from the various vaccine groups and were studied serologically as described. In the Tonga study, the hemagglutination inhibition technique alone was used for monitoring serologic conversion.

Each study is summarized below.

1.1 Jet Injection Vaccination in Persons Previously Vaccinated But Not Within the Past Five Years (Study 1)

One hundred and forty-one adult male volunteers were allocated to six study groups of 22-26 persons each. One group was vaccinated by the standard multiple pressure technique using undiluted vaccine. Each of the other five groups was inoculated with 0.1 cc. of a different dilution of the vaccine by jet injection. Dilutions employed were the 1:10, 1:100,

1:1,000, 1:10,000, and 1:100,000 dilution. Results of these studies are summarized in Table II.

It was concluded that jet injection of 0.1 cc. of the 1:10 dilution produced results as good as or better than the multiple pressure technique using undiluted vaccine. In addition, it appeared that the 1:100 dilution probably was as acceptable as the multiple pressure technique with undiluted vaccine, although the persistent slight difference between the 1:10 and 1:100 jet injection groups indicated that optimal concentration of the virus was probably to be found between these levels.

### 1.2 Primary Vaccination of Jamaican Children (Study 2)

Some 900 Jamaican children never previously vaccinated received vaccination either by the jet injection technique with 1:10, 1:50, 1:100, and 1:1,000 dilutions or by multiple pressure with undiluted vaccine. Results are summarized in Table III.

It was concluded that for primary vaccination the 1:10 and probably the 1:50 dilutions by jet injection were as good as multiple pressure using undiluted vaccine and were clearly better than the 1:100 dilution. The absence of serologic work in the 1:50 group precluded clear-cut endorsement of the dilution at that time.

### 1.3 The 1:50 Dilution in Recent Revaccinees (Study 3)

One hundred and forty adult males, most of whom could be documented as having been vaccinated within the past five years, were divided into four groups of 33-37 men each. To each of the groups was administered either a multiple pressure vaccination with undiluted vaccine or vaccinations by jet injection with the 1:10, 1:50, or 1:100 dilution of vaccine. These data are summarized in Table IV. It was noted that almost all subjects receiving

the multiple pressure, 1:10, and 1:50 schedules developed maximal areas of erythema more than 1 cm.<sup>2</sup> during the first four days after vaccination, indicating a high degree of hypersensitivity. Those in which erythema persisted at more than 1 cm.<sup>2</sup> through day 7, however, were considerably less. Vesicle formation occurred in 86% of those in the multiple pressure group and 94% of the 1:10 group, while both erythema of 1 cm.<sup>2</sup> and vesiculation were less frequently observed in those receiving the 1:50 and 1:100 dilutions.

It was concluded from this and the serologic data that the 1:10 dilution by jet injection was probably a better immunizing challenge in recent revaccinees than either undiluted vaccine by multiple pressure or any of the other dilutions by jet injector. However, it is difficult to say whether or not the 1:50 dilution by jet injection is as good as the standard multiple pressure technique in such subjects.

#### 1.4 Mass Field Trial of Primary Vaccination - Tonga Islands (Study 4)

In Tonga (Friendly Islands) in 1964, a large field trial was conducted. There has been essentially no vaccination done in Tonga during the last 50 years and no smallpox has been known in the country during this period of time; thus, the population was almost totally unvaccinated. The islands may be divided into four geographic areas. In each of these areas, a different schedule of vaccination was performed using multiple pressure undiluted vaccine, jet injector 1:10 vaccine, jet injector 1:50 vaccine, and jet injector 1:100 vaccine. An attempt was made to revisit every area for readings about 14 days after vaccination. Seventy percent of those vaccinated were thus evaluated. A smaller study of the same design was done in school children in the island capital of Nuku 'Alofa where almost all children were evaluated on the 14th day and, in addition,



a pre- and post-blood specimen was taken from every 20th child. These were monitored for serologic conversions by the HAI technique.

The results are summarized in Table V. It will be noted that the multiple pressure technique and the jet injection techniques employing the 1:10 and 1:50 dilutions produced take rates in excess of 98% but that with the 1:100 dilution overall rates fell to the 95% level. In the smaller study (Table VI) in school children, serologic studies show similarly that the 1:100 dilution was not as effective as the 1:10, 1:50 dilutions and the standard multiple pressure techniques. In this group of school children, all four techniques were observed to produce clinical results of 98% or better; the serologic results in the 1:100 dilution show a fall to the 95% level in this group.

It was concluded that the 1:50 dilution was the optimal dilution for consistent success in primary vaccination. This study also demonstrated the reproducibility of satisfactory results with jet injection and the applicability of the technique in difficult field situations.

## 2. Studies in Brazil

The studies described here constitute a further elaboration in the evaluation of jet injection smallpox vaccination. They were designed basically to demonstrate the integration of jet injection into an ongoing smallpox control program in an endemic area.

Amapá is a territory in northern Brazil consisting of about 80,000 people residing in urban and rural setting of equatorial Brazil. The territory is roughly the size of the state of Wisconsin and is bordered on the east and south by the Amazon River and the Atlantic Ocean and in the west by the border of French Guiana and the state of Pará. The studies undertaken in Amapá were designed with six objectives:

1. To vaccinate as many people in the territory as possible in the briefest period of time.
2. To demonstrate and evaluate the use of jet injector equipment in field conditions representative of the Brazilian interior.
3. To compare the population response to accepted house-to-house multiple pressure techniques with that to mass vaccination by jet injection to determine whether or not the jet injector could be utilized in expediting the present campaign.
4. To determine the efficacy of Brazilian-produced vaccines when administered in various dilutions by jet injectors.
5. To compare by clinical and serological means the efficacy of the Brazilian egg vaccine with the Brazilian calf vaccine when used by jet injection.
6. To establish a series of areas vaccinated by different techniques to assess the influence of these variables on the pattern of naturally occurring smallpox with the passage of time.

Thus, a significant part of the study was devoted to evaluation of public health program methodology in smallpox immunization and investigating promotional and programming problems. A total of 48,000 people were vaccinated in the territory in 20 operating days by various means. Certain clearcut advantages of jet injection were demonstrated by the campaign and have been reported to the Pan American Health Organization.

Of scientific interest, however, are three studies which comprise further medical evaluations of jet injection. The large urban campaign will also be briefly discussed.

2.1 Comparison of Population Response to House-to-House Multiple Pressure Campaigns with Mass Vaccination Jet Injection Campaigns in Two Small Towns (Study A)

The cities of Amapá (population 1,638) and Mazagão (population 974) were selected for comparison of the efficacy of the jet injection campaign with that of the standard house-to-house multiple pressure technique. Amapá was vaccinated by jet injection using a 1:50 dilution. A medical post was established where vaccinations were performed. After 3 hours' operation of this center, the injector was taken into the streets and carried street by street to vaccinate persons not having reported to the medical post. In Mazagão, 34 trained vaccinators were sent house-to-house performing multiple pressure smallpox vaccinations with the undiluted vaccine. Brazilian egg vaccine was used in both cities.

Thirteen hundred and thirty-five persons were vaccinated in Amapá during the day and one-half of operation, or 81.5% of the estimated population. In Mazagão, 911 of the 974 residents were vaccinated for a total of 93.5%. The results of the campaigns in both cities are compared in Table VII.

As will be noted, the house-to-house technique was more effective in reaching a greater percentage of the population.

One week following the campaign, random sample surveys were conducted in the two cities. In Amapá, a total of 80 households of the 287 households in the town were sampled, and in Mazagão 60 of 197 households were sampled. Family members of the sample households were interviewed to determine the actual percentage of the population reached by the campaign and to assess the results of vaccination. It was shown that 40% of the persons missed in the

vaccination campaign in Amapá were not in that city at the time of the campaign but in the capital city of Macapá, the interior, or other parts of Brazil. In Mazagão, only 13% of those persons missed were actually out of town.

As will be noted in both primaries and revaccinees, there was a significant and consistent increase in the effectiveness of vaccination with the jet injection technique. Thus, the overall take rate in Amapá following jet injection was fully 10% higher than that observed in Mazagão following multiple pressure inoculations. When this is taken into consideration, the percent of effective vaccination of the available population is somewhat higher in Amapá than in Mazagão despite the fact that a larger proportion of the total population of Mazagão was reached by the campaign. Of interest to the public health programmer is the advantage in production of vaccinations per man-hour expended. Well over three times as many man hours were required by the multiple pressure technique to vaccinate somewhat more than half as many people.

It was concluded from this study that: Consistently higher take rates were observed when vaccinations were performed by jet injection; a jet injection campaign even in small, semi-rural areas can result in significant reduction in the amount of time and personnel required, and a significant increase in the man hour production of vaccinations.

## 2.2 Comparison of the 1:50 Dilution U.S. Vaccine and the 1:50 Dilution Brazilian Calf Vaccine in Well-Vaccinated Populations (Study B)

Two population groups (Pôrto Santana and Serra do Navio) consisted of industrial villages at two ends of the railroad. Both these groups had been previously vaccinated within the past six months. The population of Serra do Navio was revaccinated using the 1:50 dilution of U.S. lyophilized

vaccine and the population of Pôrto Santana was inoculated with the 1:50 dilution of Brazilian calf vaccine.

The results of this study are summarized in Table VIII. Out of 62 primary vaccinations performed by the 1:50 U.S. vaccine, 59 had a classic Jennerian vesicle 7 days after vaccination. Of the remaining 3, 2 had papule formation without vesicle formation, and one had erythema at the site of inoculation on day 7. The overall rate in primaries with the 1:50 U.S. vaccine, therefore, was adjudged at 95.2%, although subsequent development of lesions beyond the 7th day in the 3 negative reactions may well have increased this to 100%. In the Pôrto Santana area (1:50 Brazilian vaccine), all primary vaccinees examined developed typical Jennerian vesicles. With respect to revaccination, 88.2% of revaccinees vaccinated with the 1:50 U.S. vaccine developed lesions which met the WHO criteria for major reactions. In contrast to this, only 76.3% of revaccinations performed with the 1:50 Brazilian calf lymph resulted in reactions adjudged as major by WHO criteria. This difference between major reaction rates following revaccination with the two vaccines is found to be highly significant statistically. However, the medical epidemiologic significance of this difference is not readily apparent.

It was concluded from this study that the Brazilian lyophilized calf vaccine compared favorably in clinical use with the U.S. lyophilized vaccine in performance of primary vaccinations, but that a difference of poorly understood significance exists between the two vaccines at that dilution level in the performance of satisfactory revaccinations.

### 2.3 Special Study Comparing Brazilian Egg and Brazilian Calf Vaccines by Jet Injection (Study C)

The site selected for this study, Ferreira Gomes, is a village in central Amapá with a population of 600 people. The first 200 individuals

to report to the medical post on the day of the study were divided into two groups, those with and those without successful previous vaccinations. Alternate persons in the two groups were vaccinated with either the Brazilian calf vaccine at a 1:10 dilution or the Brazilian egg vaccine at the same dilution. Prior titration data on the two vaccines indicated that in the undiluted form both vaccines contained approximately  $10^{8.2}$  pock-forming units per cc. The calculated amount introduced by jet injection, therefore, approximated  $0.6 \times 10^6$  P.F.U.

The village in question was visited on the 7th day after vaccination and 142 of the total were found with an age group distribution representative of the entire original group. Each vaccination was read using WHO criteria, and the data are summarized in Table IX. No significant differences between the two vaccine groups were found in either primaries or revaccinees.

On the 21st day, a house-to-house canvass of the population was made in order to obtain a convalescent blood specimen from all participating in the program. Paired sera were obtained on 165 persons. Serologic results are not as yet available. It was concluded from the clinical findings that there exists no difference between the Brazilian egg and Brazilian calf vaccine, under the circumstances in which they were used.

#### 2.4 The Macapá Mass Vaccination Campaign

The City of Macapá, with a population of 35,700, was selected as the site for a mass vaccination campaign using only jet injectors, in order to evaluate this technique in performing a large urban campaign.

With a moderate amount of pre-campaign publicity, the campaign was conducted on the basis of establishing 6 posts throughout the city, which operated for two days. Following this, the injectors were taken into the street for a street-sweeping operation on the morning of the third day.

Data are summarized in Tables X-A and X-B. The cumulative percentage of the population vaccinated during the first two days' activities was 85.5% of the population. The street-sweeping operation on the third day raised the cumulative percentage to 91.6% of the population and 212 persons vaccinated the morning of the fourth day at the General Hospital during one hour of operation of one gun raised this percentage to 92.3%.

The subsequent survey conducted in the City of Macapá one week after the campaign revealed that, of persons residing in Macapá, 84.6% had been vaccinated during the campaign. 69.9% of the population were vaccinated in the centers, 5.9% in the streets, and 7.3% in their households as part of the street-sweeping operation.

The program demonstrated the possibility of marshalling a large proportion of the population to vaccination centers for rapid vaccination over a two-day period. As will be noted in the table, a total of 360.8 vaccinations per hour of operation of the jet injectors was realized during the first day. A total of only 41 vaccinations per hour of operation of the guns on the day of the street-sweeping operation was realized.

### 3. Summary of Information Gained from the Brazilian Study

The technique of mass vaccination by jet injection was found to be applicable in the Brazilian campaign. Advantages, including reduction in vaccine costs, in manpower needs, and in transport costs, were documented.

Throughout the study, irrespective of the type of vaccine used, jet injection produced take rates of 95% or better in primaries and "major" reactions of 85% or better in revaccinations. This is contrasted with the significantly lower rates observed with multiple pressure vaccination in the Brazilian campaign. It should be noted that a significant difference

exists between the rates of primary vaccinations as performed by Brazilian field vaccinators and those demonstrated by experienced vaccinators in our previous studies. Whereas 97% or better multiple pressure vaccinations performed in Tonga were followed by primary takes, 85% of multiple pressure vaccinations in the Mazagão area in Brazil were observed to result in primary takes. This difference is related undoubtedly to the personnel involved in the two campaigns. The majority of multiple pressure vaccinations in Tonga were done by members of the U.S. team who have had several years of experience with the multiple pressure method. Multiple pressure vaccinations in Brazil were performed by local vaccinators recruited and trained in the pattern similar to that being done throughout the Brazilian smallpox eradication campaign.

In the Brazilian work, a consistent 10% increase in the effectiveness of primary and revaccinations was observed when vaccinations were performed by jet injection. Because of the consistency of the results following jet injection, it was concluded that the routine reading of vaccinations could probably be dispensed with by the use of jet injectors.

On the basis of the Amapá studies, it is concluded that it is entirely feasible to stimulate urban and suburban populations in Brazil to respond to a jet injection oriented vaccination campaign. The efficiency of jet injection is directly related to the size of the population to be approached. However, even in smaller semi-rural communities, obvious advantages in vaccinations-per-man-hour-expended were realized.

Brazilian vaccines were generally found to be effective when used by jet injection. The 1:10 dilution of both Brazilian egg and Brazilian calf vaccine appeared to be fully effective and similar. Take rates among recent revaccines when using the 1:50 dilution of Brazilian calf vaccine was



observed to be lower than those with the use of the 1:50 U.S. vaccine but this apparent difference must be further explored under conditions of a well-controlled clinical trial before the 1:50 dilution can be considered not acceptable in the Brazilian campaign.

The jet injector equipment as used by the team in the field functioned well throughout with minimum problems, despite its being used by largely untrained, local personnel. A qualified jet injector technician was present with the team at all times and is considered to be essential to effective operation of the campaign.

In conclusion, the studies described above in Brazil largely satisfied the objectives of appraising its applicability to large-scale, mass field use in an endemic area, in addition to providing certain opportunities for further medical evaluation of the instrument. The ultimate effectiveness of jet injection will be finally substantiated only with continuing surveillance of the occurrence of smallpox in the area studied, and a definition of duration protection afforded by the technique as measured in this epidemiologic way.

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TABLE I

JET INJECTION SMALLPOX VACCINATION  
VACCINIA VIRUS TITERS  
LYOPHILIZED SMALLPOX VACCINE (DRYVAX, WYETH)  
GIVEN TO STUDY GROUPS

Vaccine	Volume after Reconstruction	Titer TCID <sub>50</sub> /ml	Amount of Virus (TCID <sub>50</sub> ) in Total Volume Prepared	No. Doses	Dose	Amount Virus Injected
Undiluted	0.3 cc	$3 \times 10^8$	$1 \times 10^8$	10	1 drop	?
1-10	10 cc	$1 \times 10^7$	$1 \times 10^8$	100	0.1cc	$1 \times 10^6$
1-50	50 cc	$2 \times 10^6$	$1 \times 10^8$	500	0.1cc	$2 \times 10^5$
1-100	100 cc	$1 \times 10^6$	$1 \times 10^8$	1,000	0.1cc	$1 \times 10^5$
1-1,000	1,000 cc	$1 \times 10^5$	$1 \times 10^8$	10,000	0.1cc	$1 \times 10^4$

COMPARISON OF JET INJECTION AND MULTIPLE  
 PRESSURE IN REVACCINATION OF ADULTS  
 PREVIOUSLY VACCINATED MORE THAN 5 YRS. IN THE PAST

TABLE II

Group	No.	Mean age (yrs)	Mean Time since Last Vaccination (years)	Number with		Percent with Erythema 1cm or more Day 7	Percent with Vesicle Formation	Percent with 4-Fold Titer Rise	
				Pre-Vacc. Titer < 160	> 160			Pre-Vacc. Titer < 160	Total
Multiple Pressure	23	41.2	15.6	20	3	100%	100%	80%	74%
Jet Injection: 1-10 Dilution	22	33.6	19.6	19	3	77	100	90	82
1-100 Dilution	22	30.3	17.6	18	4	82	73	67	63
1-1,000 Dilution	24	32.2	20.8	20	4	21	29	10	8

TABLE III  
 COMPARISON OF JET INJECTION AND  
 MULTIPLE PRESSURE PRIMARY VACCINATION  
 RESPONSE IN JAMAICAN CHILDREN

Group	No. in Group	Mean Age	Percent Clinical "Takes"	Percent Neutralizing Antibody Conversion
<u>Pre-School</u>				
Multiple Pressure (Fresh Lymph)	15	3.6	93%	92%
Jet Injection: 1-100 Dilution	26	2.7	92	91
<u>School Age</u>				
Multiple Pressure: Fresh Lymph	42	6.3	98	100
Lyophilized Lymph	49	6.1	96	95
Jet Injection: 1-10 Dilution	165	7.0	98	100
1-50 Dilution	112	5.2	97	**
1-100 Dilution	187	6.6	89	91
1-1000 Dilution	118	6.6	62	**

\*\* Not done.

COMPARISON JET INJECTION AND MULTIPLE PRESSURE VACCINATION IN RECENT VACCINEES

TABLE IV

A. CLINICAL RESPONSE													
Group	No.	Mean Age	Time Since Last Vaccination		Mean	Maximum Response Erythema 1 cm. 2 or more	Erythema 1 cm. 2 or more day 7	Vesicle Formation	4-Fold Neut. Rise After Vaccination Pre-Titer				
			< 5 yrs.	> 5 yrs.					Number	Percent	Number	Percent	Number
Multiple Pressure	37	38.2	25	12	6.9	35	24	32	94%	20	65%	33	86%
Jet Injection	35	37.5	16	19	9.4	32	14	57	91	57	42	33	94
1-10 Dilution	33	35.8	18	15	9.2	32	14	42	97	42	46	23	70
1-50 Dilution	35	39.0	16	19	11.1	25	16	46	71	46	46	18	51
B. SEROLOGIC RESPONSE													
Group	No.	Pre-Vacc. Neutralizing Titer		4-Fold Neut. Rise After Vaccination Pre-Titer				Total					
		≤ 160	> 160	≤ 160	> 160	No.	Percent	No.	Percent				
Multiple Pressure	37	13	24	9	69%	3	12%	12	32%				
Jet Injection	35	18	17	13	72	6	35	19	54				
1-10 Dilution	33	13	20	9	69	0	-	9	27				
1-50 Dilution	35	16	19	6	37.5	3	15.7	9	26				

TABLE V

GRAND TOTAL KINGDOM OF TONGA: SMALLPOX VACCINATION RESULTS - 1964

District	Principal Method	Number Vacc.	Number Read	Percent Read	Takes	No Takes	Take Rate
'Eua	Multiple Pressure	1,384	1,165	84.2%	1,163	2	99.74%
Ha'apai	Jetgun, 1:10	6,358	4,825	75.9	4,806	19	99.61
Tongatapu	Jetgun, 1:50	29,414	19,391	65.9	19,173	218	98.87
Vava'u	Jetgun, 1:100	7,134	4,965	69.5	4,731	234	95.28
GRAND TOTAL	All Methods	44,290	30,346	68.5	29,873	473	98.44

HAI ANTIBODY CONVERSIONS COMPARED WITH CLINICAL RESULTS IN 325 ELEMENTARY SCHOOL CHILDREN  
 TONGA - 1964

Group	Number Vaccinated	Overall Clinical Take Rate	No. From Whom Sera Obtained	No. With Clinical Takes	Clinical Take Rate in Study Group	Number Serologic Conversions	Sero Take Rate	Geom. Mean Post-Vacc. Titer
Multiple Presure	1,766	97.8%	96	96	100%	96	100%	84
Jet Injection 1:10 Dilution	1,820	99.7	105	105	100	105	100	96
Jet Injection 1:50 Dilution	1,992	99.5	94	94	100	94	100.	168
Jet Injection 1:100 Dilution	2,016	98.2	100	99	99	97	96.4	106



TABLE VII

COMPARISON OF HOUSE TO HOUSE MULTIPLE PRESSURE CAMPAIGN  
WITH JET INJECTOR CAMPAIGN IN TWO SMALL INTERIOR CITIES\*

Item	Mazagão	Amapá
Urban population	974	1638
Campaign Method	House-to-House	Post and Street by Street Mopup
Method of Inoculation	MP	Jet
Vaccine	Brazilian Egg	Brazilian Egg
Dilution	none	0.3cc in 50cc saline
Amount	17 tubes	1 tube
Percent of Total Population Vaccinated	89.6%	78.6%
Percent of Unvaccinated Persons Not Available for Vaccination	13.0%	40.0%
Percent Available Population Vaccinated	90.4%	86.1%
Take Rate Overall	80.8%	90.1%
Primaries	84.6	95.3
Revaccinees	76.1	86.7
Percent Effective Vaccination of Available Population	73.0%	77.6%
No. of Personnel Utilized	38	5
Vaccination per Man Hour	8.0	40.5

\* Based on post campaign survey.

TABLE VIII

VACCINATION OF WELL-VACCINATED POPULATION BY JET INJECTOR  
 COMPARISON OF 1:50 U.S. AND 1:50 BRAZILIAN  
 CALF LYMPH SMALLPOX VACCINE

Item	Serra do Navio	Vila Amazonas
Population	2033	1841
No. Vaccinated	1725	1809
Percent Vaccinated	84.8%	98.3%
Vaccine Used	Calf, US 1:50	Calf, Brazilian 1:50
Method	Jet Injector	Jet Injector
Percent Primary Vaccinations	4.3%	13.2%
Method of Reading	Call Back	Random Sample*
Number Read:	1434	223
Primaries	62	16
Revaccination	1372	207
Percent Positive:		
Primaries	95.2%	100%
Revaccination	88.2%	76.3%

\* 40 household sample.

TABLE X-A

MACAPÁ: VACCINATIONS

Age Group	Daily Number of Persons Vaccinated*				
	Monday	Tuesday	Wednesday	Thursday	TOTAL
3 mo.-4 years	4453	1847	399	31	6730
5-9 "	4605	1365	285	11	6266
10-14 "	3767	1060	252	16	5095
15-29 "	4448	2399	585	76	7508
30-49 "	2992	1458	460	58	4968
50+ "	1385	757	232	20	2394
TOTAL	21,650	8,886	2,213	212	32,961

  

Category	Percent Vaccinated				
Total vaccinations	65.7	27.0	6.7	0.6	100.0
Population vaccinated	60.9	24.6	6.2	0.6	92.3
Cumulative % of population vaccinated	60.9	85.5	91.7	92.3	

\* Brazilian Calf Vaccine 1:50 used exclusively in Macapá.

TABLE X-B

MACAPÁ: OPERATIONAL DATA

Day of Week	Vaccination Teams	Gun Hours	Vaccination per Gun-Hr.	Man Hours			Vaccination per Man-Hr.
				Team	Local	Total	
Mon.	6 centers	60	360.8	60	400	460	47.1
Tues.	5 centers 1 mobile team	60	148.1	40	400	440	20.2
Wed.	6 mobile teams	54	41.0	54	360	414	5.3
Thurs.	1 center	1	212.0	1	0	1	212.0
TOTAL		175	188.3	155	1160	1315	25.1

TABLE IX

FERRERIRA GOMES STUDY GROUPS

Age Group (yrs)	Calf Vaccine				EGG Vaccine				
	Primary*		Revaccination		Primary*		Revaccination		
	Vacc.	Read	Vacc.	Read	Vacc.	Read	Vacc.	Read	
5-14	35	20	25	16**	28	20	20	22	25
15-29	15	10	10	10	15	8	12	16	11***
30-49	8	4	6	6	10	8	8	4	2
50+	2	0	0	2	1	0	1	4	3
TOTAL	60	34	41	34	54	36	41	54	38

\* 100% overall take rate.  
 \*\* Includes 1 negative reading, 97.1% overall take rate.  
 \*\*\* Includes 2 negative readings, 94.7% overall take rate.