Responses to Smallpox Vaccination in Military Recruits

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THE IMMUNITY of young men to contagious diseases is being studied in a group of recruits from the Army, the Navy, and the Air Force, and preliminary and secondary reports of a survey of this group carried out during April–June 1951 have been submitted to the Surgeon General of the Army. These reports include details of the manner in which the vaccination survey was conducted and definitions of the geographic divisions of this country and of the home communities of the recruits. Reports have been published on the results of Schick tests in relation to geographic origin and residence (*1*) and on the results of mumps complement fixation tests (*2*).

The survey reported here was carried out to determine the results of smallpox vaccination as practiced by the Armed Forces under conditions existing in early 1951 and to consider how such measurements can be used as a national index of certain vaccination practices. It was felt that this group, although subject to some bias in its selection, was nevertheless quite representative of the population of the Nation. The study does not, of course, represent an investigation to determine how thoroughly all young adult males of this country have been vaccinated.

A number of attempts have been made to review the extent of mass immunity against smallpox in the population of this country. Collins (*3*) found that, for the 4-year period 1928–31, 54 percent of almost 40,000 individuals of all ages residing in various parts of this country had been vaccinated. Of the males in his series, 65 percent of 2,415 individuals aged 15–24 years had been vaccinated, and 4 percent of the same group stated that they had had a clinical attack of smallpox.

Bull and Rankin (*4*) analyzed the records of 5,488 students who were vaccinated between 1924 and 1936 after admission to Lehigh University. Only 193 (3.5 percent) had not been vaccinated before entering the university, and 7.5 percent of the entire group gave a primary reaction to vaccination. Loy and Husband (*5*, *6*), in 1936 and 1937 found that 75 percent and 78 percent of two groups of students of about 1,000 each had been vaccinated before entering another university. They came mainly from rural areas and small towns of Kansas. About 60–65 percent of them were considered "susceptible to vaccination," as shown by a primary or a vaccinoid reaction.

More recent information on the response to smallpox vaccination of the general population of this country is rather fragmentary. I have been unable to find a report based on data collected within the past 20 years on a nationwide

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basis; therefore, the results of the present study might be considered to be a progress report on a national basis.

The manner in which this vaccination survey was conducted has been similar to that recorded in earlier reports to the Surgeon General of the Army. All of the recruits were males. The only criteria of selection were: (*a*) that the recruit be able to recall whether or not he had been vaccinated before admission to the military services and, if so, when; and (*b*) that the results of the current vaccination could be evaluated by the group making this study. Throughout this paper, the term "current vaccination" is used to mean the smallpox vaccination done by Armed Forces personnel when this survey was conducted in 1951.

About 95 percent of the entire group examined were between 17 and 22 years of age. The recruits came chiefly from the North Central and the Southern States and were more or less evenly distributed among urban, town, and rural communities. All were apparently in good health and none reported a clinical attack of smallpox.

Smallpox Vaccination

The recruits who were entering the Army, the Navy, or the Air Force, were vaccinated at the processing centers when they were inducted—2 to 7 days, usually 4 days—prior to their arrival at the training camps where the surveys were conducted. These training camps were: Fort George G. Meade, Md.; Aberdeen Proving Grounds, Md.; Lackland Air Force Base, Texas; and Great Lakes Naval Training Center, Ill. The actual vaccination procedure was carried out by medical personnel of the Armed Forces. The vaccination responses were read by a group of third- and fourth-year medical students from the Yale University School of Medicine and were recorded twice. The first reading was usually taken 5 to 9 days after the vaccination and the second reading, 4 days later. These readings were often supplemented by examining the immunization records of the recruits for reports of earlier readings made by others during the current period of observation.

Classification of the responses to smallpox vaccination was that recommended by Leake (*7*) and readings were evaluated, in relation to the time of vaccination, as "primary," "accelerated," and "immune" reactions. The corresponding terms preferred by some authors to describe similar types of responses to smallpox vaccination are "vaccinia," "vaccinoid," and "immediate" reactions. Each time the responses were read, measurements of the erythematous area were taken carefully, and the character and size of the vesicle or pustules were recorded.

In interpreting vaccination results, only the primary reaction was considered to be an indication of lack of specific immunity (*8*). No emphasis was laid on the accelerated and immune reactions for a number of reasons, some of which have been emphasized by Horgan and Haseeb (*9*). These authors have indicated that possible erroneous results may be due to differences in the skill of the operator and to the potency of vaccine lymphs. They suggested that such variations are even more important in revaccinations than in primary vaccinations. In line with these observations are those of Benenson, Kempe, and Wheeler (*10*), who demonstrated that even an inactivated lymph (containing no live vaccinia virus) could give accelerated or immune reactions in repeatedly vaccinated persons similar to the reaction induced by potent lymph, although the inactivated lymph could not provoke a rise of complement-fixing antibodies or hemagglutination inhibition antibodies characteristic of the potent lymph.

Results

In the evaluation of readings at the first interview during the immunity survey, 2,682 individuals were questioned with regard to their histories of previous smallpox vaccinations. The interview was usually supplemented by an examination for vaccination scars. Almost 10 percent had never been vaccinated before entering military service (table 1). About one-half had been vaccinated more than 10 years previously and almost one-third, within the last 10 years. Few could recall having been vaccinated more than once. None reported a clinical attack of smallpox.

Table 1. History of previous smallpox vaccination and evaluability of vaccination in 2,682 military recruits

History of previous vaccinations	Total recruits interviewed		Results of current vaccination			
			Not evaluable		Evaluable	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2, 682	100. 0	393	14. 65	2, 289	85. 35
>10 years [2]	1, 510	56. 30	213	7. 94	1, 297	48. 36
<10 years [3]	882	32. 88	122	4. 55	760	28. 33
Never before [4]	258	9. 62	52	1. 93	206	7. 69
Unknown [5]	32	1. 20	6	. 23	26	. 97

[1] All percentages are based on the total of 2,682.
[2] Vaccinated more than 10 years previously.
[3] Vaccinated within the last 10 years.
[4] Never vaccinated before induction into military service.
[5] Could not remember whether or not he had been vaccinated before.

The results of the current vaccination program in 393 recruits (15 percent of the entire group) could not be satisfactorily evaluated for various reasons. The major reason for the loss of these men from the series was that a good proportion of them were not vaccinated after entering military service. Another group of recruits reported that they had been vaccinated, although the results were not marked on their immunization records nor was any scarring detectable. A very few were absent at the second reading of the vaccination responses, either because of sickness or for other causes. Among those whose vaccination results could be evaluated, 26 persons could not give a definite statement about their previous smallpox vaccination. Thus, excluding the 419 individuals in these two categories, only 2,263 military recruits were included in the subsequent analyses.

Table 2 summarizes the history of previous vaccinations and the results of the current vaccination. About 18 percent of the entire group gave a primary reaction; 48 percent, an accelerated reaction; and 33 percent, an immune reaction. Among those who had never been vaccinated before, 85 percent gave a primary reaction. A higher percentage of primary reactors were observed among those who had been vaccinated more than 10 years previously than among those who had been vaccinated within the last 10 years, although the difference was not remarkable.

Distribution of the previously unvaccinated recruits according to their geographic origins

Table 2. History of previous smallpox vaccination and result of current vaccination of 2,263 military recruits

Previous vaccination history	Vaccinated recruits with definite history of vaccination	Reaction to vaccination					
		Primary		Accelerated		Immune	
		Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2, 263	415	18. 3	1, 105	48. 4	760	33. 3
>10 years [2]	1, 927	163	12. 6	727	56. 0	407	31. 4
<10 years [3]	760	76	10. 0	343	45. 1	341	44. 9
Never before [4]	206	176	85. 5	[5] 25	12. 1	[5] 5	2. 4

[1] Percentage of total in each history group
[2] Vaccinated more than 10 years previously.
[3] Vaccinated within the last 10 years.
[4] Never vaccinated before induction.
[5] Vaccinated only once in the military services. Whether a different response could be obtained by further repeated vaccination was not investigated.

Table 3. Percentage distribution of 2,263 military recruits reporting no smallpox vaccination before induction, by type of community and geographic area of residence

Type of community	Total		Geographic area							
			Northeast		North Central		South		West	
	Number interviewed	Percent never vaccinated	Number interviewed	Percent never vaccinated	Number interviewed	Percent never vaccinated	Number interviewed	Percent never vaccinated	Number interviewed	Percent never vaccinated
Total	2, 263	9. 1	293	2. 7	920	10. 5	923	9. 3	127	11. 8
Urban	798	4. 8	189	1. 6	342	7. 0	241	2. 9	26	15. 7
Town	839	9. 4	86	4. 6	349	10. 9	356	8. 2	48	16. 7
Rural	626	14. 2	18	5. 6	229	15. 3	326	15. 7	53	5. 6

and domiciliary communities is shown in table 3. Of the 293 persons from the Northeastern States, only 8 (2.7 percent) had never been vaccinated prior to induction. These 8 were more or less evenly distributed among urban, town, and rural districts. The occurrence of such a distribution by chance was approximately 1 in 3, with $x^2=1.35$.

Nine hundred twenty recruits came from the North Central States. Almost 11 percent had never been vaccinated previously. More, previously unvaccinated, recruits from the North Central region came from rural areas than from urban communities. The difference was statistically significant ($x^2=10.3$ and $p=1$ in 1,000, approximately).

Nine hundred twenty-three recruits came from the Southern States; 9 percent had never been vaccinated before. In these States, more of the unvaccinated recruits had lived in rural areas than in urban communities. The difference was statistically significant ($x^2=23.7$ and $p<1{,}000$).

The number of recruits from the Western States was too small to subject to critical analysis.

The distribution of recruits with primary reactions to the current vaccination is shown in table 4.

Eighteen percent of the recruits from the Northeast gave a primary reaction; corresponding figures for the North Central States, the South, and the West were 19 percent, 18 percent, and 14 percent, respectively. There was no significant difference among the four geographic areas in the proportions of recruits

Table 4. Percentage distribution of primary reaction of 2,263 military recruits to current smallpox vaccination, by geographic origin and type of home community

Geographic origin	Total		Type of community					
			Urban		Town		Rural	
	Number examined	Percent primary reactions [1]	Number examined	Percent primary reactions [1]	Number examined	Percent primary reactions [1]	Number examined	Percent primary reactions [1]
Total	2, 263	18	798	15	839	19	626	22
Northeast	293	18	189	19	86	20	18	11
North Central	920	19	342	15	348	19	229	25
South	923	18	241	11	356	19	326	23
West	127	14	26	15	48	19	53	9

[1] Percentage based on number of examined recruits in each region.

with a primary reaction to the current vaccination.

Fifteen percent of the urban recruits, 19 percent of the town recruits, and 22 percent of the rural recruits gave a primary reaction to the current vaccination. The difference in percentage of primary reactions in recruits from urban communities and from rural areas was statistically significant ($\chi^2=14.2$ and $p<1$ in 1,000).

The percentage distribution of primary reactions among the recruits in individual States or groups of States is shown in table 5. The percentages regarded as significant varied from 5 to 27 percent. Factors responsible for the high values are probably multiple.

Table 5. Percentage of primary reactors to smallpox vaccination of 2,259 [1] military recruits, by individual States or groups of States

States or groups of States	Number in study	Percent primary reactors
New England States	72	22
New York and New Jersey	112	12
Pennsylvania	109	21
Maryland, Delaware, Virginia, West Virginia, and District of Columbia	80	20
North and South Carolina	175	5
Georgia and Florida	79	15
Alabama	77	22
Kentucky	90	12
Tennessee	84	25
Ohio	234	27
Michigan	168	13
Indiana	70	23
Illinois	150	17
Wisconsin	58	7
Minnesota	124	18
North and South Dakota	[2] 39	[2] 26
Oklahoma, Kansas, and Iowa	[2] 21	[2] 43
Mississippi, Arkansas, and Louisiana	121	26
Missouri	64	12
Texas	205	22
Arizona and New Mexico	[2] 21	[2] 14
Colorado, Utah, and Nevada	[2] 23	[2] 9
Montana, Idaho, and Wyoming	[2] 23	[2] 23
Washington, Oregon, and California	[2] 60	[2] 13
Total	2, 259	18

[1] For 4 of the original recruits, data on "home State" were not available.

[2] Results probably not representative, because of the small numbers of recruits included.

Twenty years ago, Collins (*3*) found that 65 percent of 2,415 males aged 15–24 years had been vaccinated and 4 percent reported that they had had smallpox. From our survey, it appeared that in 1951 the situation had been improved—approximately 90 percent of a somewhat similar age group of males (17–22 years) had been vaccinated and none reported an attack of the disease.

From our interviews with these military recruits, the impression was gained that fewer young adult males from the Northeastern States (3 percent) had not been vaccinated before entering the armed services than had those from other parts of the country—North Central, 11 percent; South, 9 percent; and West, 12 percent. Nevertheless, similar proportions of primary reactions were obtained from each of these four geographic regions.

When rural and urban communities were compared, it was found that more of the recruits from rural areas gave a primary reaction than did those from urban communities. Assuming that vaccination was performed with equal skill in both rural and urban localities, this difference could be taken merely to reflect the fact that more of the rural recruits than urban recruits had never been vaccinated before entering military service.

Because of the very nature of the population included in this survey, these results should not be taken to indicate the immunity status of the population of the United States as a whole. Nevertheless, it represents the type of survey that it is desirable to conduct from time to time to serve as an index of the general effectiveness with which vaccination against smallpox is being practiced on a regional basis throughout the country.

Summary

This survey concerns the response to vaccination as performed by Armed Forces medical personnel on United States military recruits who were vaccinated and examined at the time of their induction into the services in 1951.

Almost 2,700 male recruits, the majority aged 17–22 years, were interviewed as to their history of previous smallpox vaccination, and their responses to the current smallpox vaccination were recorded.

About 10 percent of this nationwide sample had never been vaccinated before. None reported a previous attack of smallpox. Fewer recruits from the Northeastern States than from

other parts of the country had never been vaccinated before. More recruits from rural areas than from urban communities had never been vaccinated previously.

About 18 percent of 2,263 recruits gave a "primary" reaction to the current vaccination. Of those who had never been vaccinated before, about 85 percent gave a primary reaction. More primary reactions were observed among those who had been vaccinated 10 years ago than among those who had been vaccinated within the last 10 years. However, the difference was not remarkable.

There was no difference in the proportion of primary reactions among recruits from the four geographic regions of the United States.

The percentage of primary reactions among recruits from individual States or groups of States varied from 2 percent to 26 percent.

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Legal Note—Liability for Pooled Blood Plasma

The New York Court of Claims recently held that the State of New York is not civilly liable for the death of a hospital patient who died from homologous serum hepatitis which he developed as a result of a nonemergency transfusion of pooled unirradiated blood plasma. The plasma had been distributed to the hospital, free of charge, by the State of New York. *Hidy* v. *State of New York*, 137 NYS 2d 334 (Ct. Claims, N. Y., 1955).

The court held that the State was under no duty to affix warning labels to the plasma containers nor to distribute literature concerning the dangers of pooled blood since such information was readily available to practitioners through the professional journals. The Appellate Division of the New York Supreme Court has previously held that the State cannot be held liable for the death of a patient when the contaminated blood plasma is administered under emergency conditions where "safer" types of transfusion material are not available. *Parker* v. *State*, 280 App. Div. 157, 112 NYS 2d 695 (1952), leave to appeal denied 304 NY 989, 109 NE 2d 474.