Surveillance of Poliomyelitis in the United States in 1956

COLLECTION and dissemination of epidemiological data on the safety and effectiveness of poliomyelitis vaccine are the primary functions of the National Poliomyelitis Surveillance Program, which was established in April 1955 at the Communicable Disease Center of the Public Health Service. These data are summarized and distributed currently in the mimeographed Poliomyelitis Surveillance Reports, which are available to all persons with responsibility in the control of poliomyelitis. A review of information collected in 1955 has been published (*1*). The present report summarizes the data for 1956.

As part of the surveillance program a clearinghouse of information is maintained in the Poliomyelitis Surveillance Unit, Communicable Disease Center. There is constant mutual exchange of data between the unit and State and local health departments, virus diagnostic laboratories, the National Foundation for Infantile Paralysis, and others. More than 40 officers of the Communicable Disease Center's Epidemic Intelligence Service contribute to this activity.

This report was prepared by the staff of the Poliomyelitis Surveillance Unit: Dr. Neal Nathanson, chief; Dr. William Jackson Hall, assistant chief; Dr. Lauri D. Thrupp, epidemic intelligence service officer; and Helen Forester, statistician. The unit is part of the Epidemiology Branch (of which Dr. Alexander D. Langmuir is chief), Communicable Disease Center, Public Health Service, Atlanta, Ga.
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Poliomyelitis Incidence in 1956

During 1956 a total of 15,400 cases of poliomyelitis were reported to the National Office of Vital Statistics, Public Health Service, a rate for the United States of 9.2 cases per 100,000 population. This is the lowest rate reported since 1947. Marked annual variations in poliomyelitis incidence are apparent from a comparison of rates for the years 1910 through 1956 (fig. 1) and from a comparison of poliomyelitis incidence by weeks for 1956 with the years 1946 through 1955 (fig. 2). Because of these wide annual variations in incidence, it is not yet possible to attribute the low incidence reported in 1956 to the widespread, although incomplete, use of poliomyelitis vaccine. Further decreases in incidence over the next several years may be of greater significance.

The 1956 incidence rates for six geographic regions, with median rates for the period 1951–55, appear in table 1. The highest regional rates in 1956 were in the Southwest, the South Central, and the North Central States; these same regions also had the highest 5-year median rates. Lowest 1956 rates and lowest 5-year median rates were reported for the Northeast and the Southeast.

For individual States a similar comparison of 1956 rates with 5-year median rates appears in figure 3. (The number of cases reported in 1956 for each State, by paralytic status, is given in table 2.) The four States with the highest 1956 rates were Utah, Iowa, Louisiana, and Illinois, in that order. None of these States experienced particularly low median rates for the previous 5 years. The high 1956 incidence in Utah reflects an epidemic in Salt Lake City and the surrounding area. The cases reported

from Iowa undoubtedly include many cases of nonpoliomyelitis viral meningitis since less than 10 percent of the cases were reported as paralytic and since isolations of Coxsackie virus were reported from outbreaks in four areas of the State. Only in Louisiana did reported incidence exceed the 5-year median; high endemic rates were reported in several areas of this State. The largest concentrated outbreak during 1956 occurred in Chicago. More than 1,100 cases were reported, a rate of about 30 per 100,000.

Vaccine Safety

Surveillance of vaccine safety is based primarily on analysis of poliomyelitis cases occurring within 30 days of a poliomyelitis vaccination. Cases of this kind are routinely reported to the Poliomyelitis Surveillance Unit by all State and Territorial health departments. In addition, this phase of the program includes collection of some data on possible reactions to the vaccine.

Poliomyelitis Following Vaccination

With more than 70 million inoculations of vaccine given during 1956 and with considerable amounts of vaccine used in high-incidence areas, it is clear that by coincidence alone a large number of cases would be expected to occur shortly after vaccination. Thus, the purpose of surveillance of vaccine safety is to determine whether coincidence is an adequate explanation for all the cases occurring shortly after vaccination. It must be recognized, now that vaccine is frequently used during periods of high incidence, that epidemiological methods may not detect the occurrence of small numbers of vaccine-related poliomyelitis cases.

Cases are currently analyzed for (*a*) excessive frequency of association with individual lots of vaccine, (*b*) concentration within the 4- to 11-day period of the intervals between inoculation and onset, and (*c*) correlation between sites of inoculation and sites of first paralysis. These were the distinguishing epidemiological characteristics of the cases in 1955 associated with vaccine manufactured by Cutter Laboratories (*1*).

During 1956, 500 under-30-day cases were reported, 229 of which were paralytic. (This total does not include a group of more than 300 cases in Chicago, which will be discussed in a later section of this paper.) Comparison of these 229 paralytic cases with the 70 million doses of vaccine administered gives an average ratio of about 1 paralytic case for every 300,000 inoculations. Classification of cases according to manufacturers and lot numbers of the vaccine used showed that only 5 lots distributed in 1956 were associated with more than 5 paralytic cases, while half (67) of the lots were not associated with any paralytic cases. Analysis of the 5 lots associated with more than 5 paralytic

Figure 1. Annual poliomyelitis incidence rates in the United States, 1910–56.

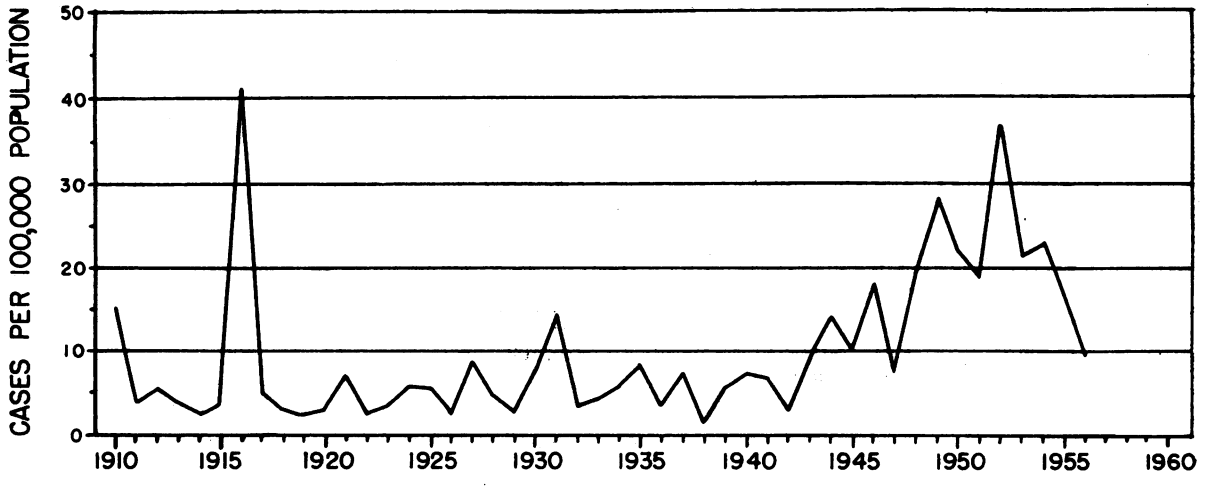
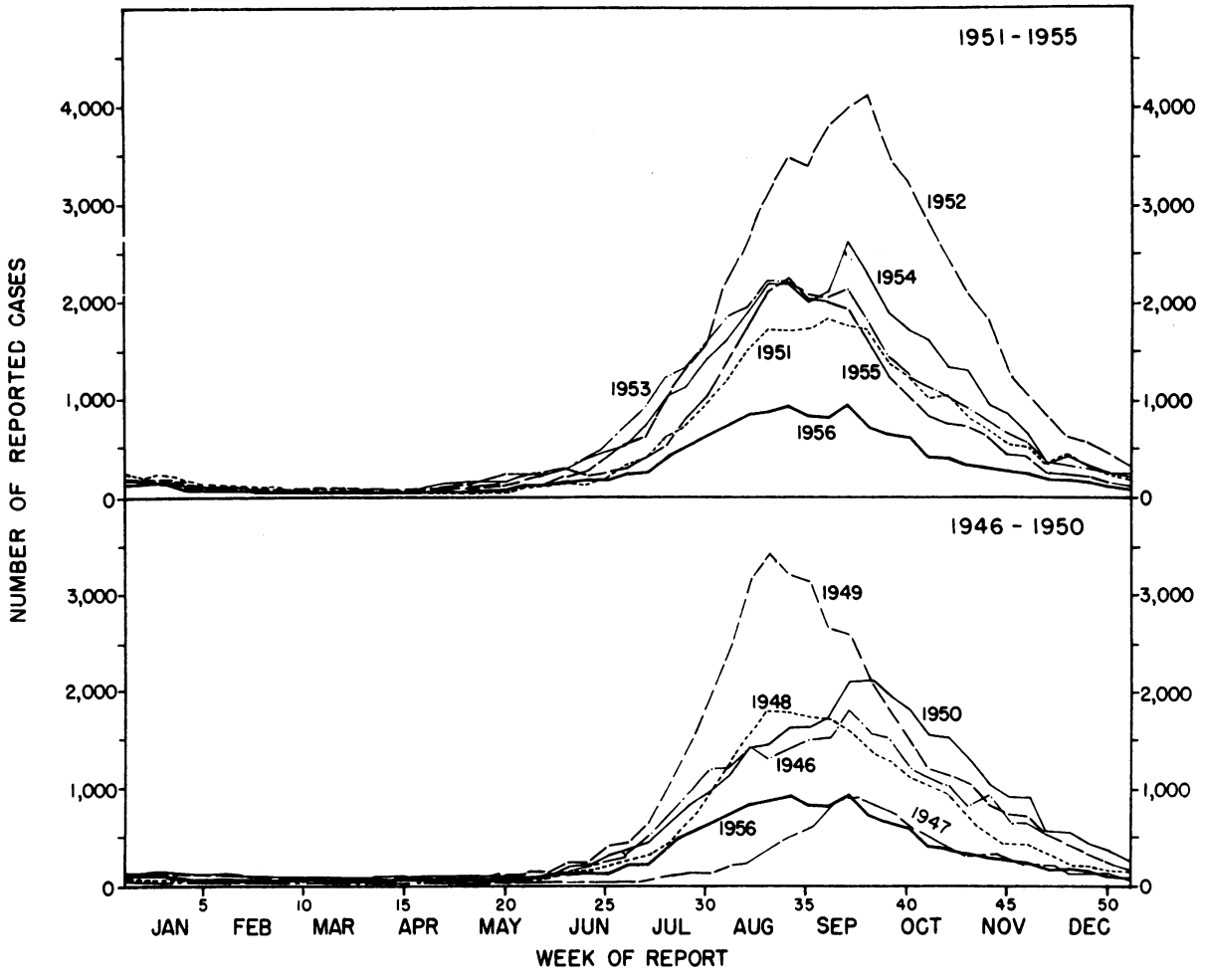


Figure 2. Poliomyelitis incidence in 1956 compared with the years 1946 through 1955.



NOTE: Data provided by National Office of Vital Statistics, Public Health Service.

cases showed that in all instances these lots had been used during the summer and in areas experiencing high or epidemic incidence of the disease and that these cases did not exhibit the other epidemiological characteristics of the Cutter cases.

When intervals between inoculation and onset were examined for the 229 paralytic vaccinated cases, it was found that 53 percent of the cases occurring 0–15 days after inoculation fell in the 4- to 11-day period, very close to the 50 percent expected by chance. The corresponding percentage for the Cutter cases was 88.

Analysis of the relationship between sites of inoculation and first paralysis showed the following: Of the 229 paralytic cases, 164 had spinal involvement, and of these 164, the site of inoculation was known for 150. Among these 150, initial involvement included either the inoculated or the opposite uninoculated extremity, or both, in 31. Of these 31, only the inoculated limb was involved in 21, only the opposite uninoculated limb was involved in 6, and both limbs were involved in 4. This slight excess of correlated cases (21) over uncorrelated cases (6) may indicate the occurrence of a small number of vaccine-related cases. However, the correlated cases were spread among 19 lots of vaccine. Also, analysis of a comparison group of 905 cases that occurred more than 30 days after vaccination showed a similar excess of correlated over uncorrelated cases (13 and 6, respectively). Although the frequency of correlation in the small group of under-30-day cases suggests vaccine-related poliomyelitis, the

similar frequency of correlation for the over-30-day cases precludes any definite conclusion. However, if it is assumed that the excess of 15 correlated under-30-day cases was due to prior inoculation, then the vaccine has influenced the development of considerably less than one paralytic case per million inoculations.

Vaccine Reactions

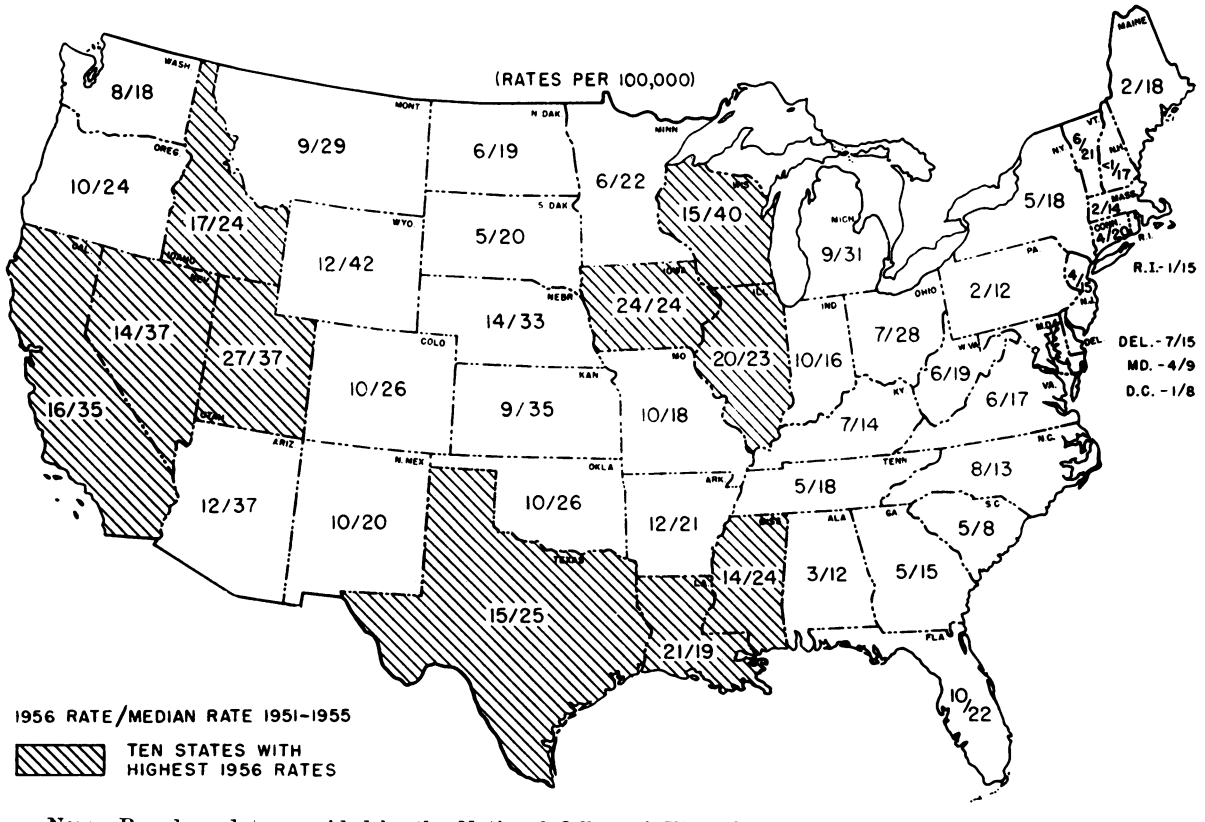
Vaccine reactions that have been considered possible hazards include encephalitis or other neurological illnesses such as may occur following use of smallpox or other vaccines; allergic reactions to the traces of penicillin and foreign proteins in the vaccine; nephritis or other renal diseases attributable to reaction to residual monkey kidney proteins in the vaccine; and sensitization of Rh negative persons by Rh positive antigen potentially present in the vaccine. To evaluate these hazards, the Poliomyelitis Surveillance Unit has collected reports of a number of nonpoliomyelitis illnesses occurring shortly after vaccination. Although the reports are undoubtedly incomplete and no final evaluation can be reached at present, the following observations can be made:

Table 1. Reported poliomyelitis incidence rates for 1956 and median rates for 1951–55, by geographic region

Region [1]	Rate for 1956 [2]	Median rate for 1951–55 [2]
United States	9.2	23
Northeast	3.5	17
North Central	11.9	27
Northwest	9.7	24
Southeast	5.9	18
South Central	15.1	27
Southwest	15.6	36

[1] See table 2 for States included in each region.
[2] Per 100,000 population.

Figure 3. Poliomyelitis incidence rates in 1956 compared with median rates in 1951–55.



NOTE: Based on data provided by the National Office of Vital Statistics, Public Health Service, and the Bureau of the Census.

Table 2. Number of poliomyelitis cases reported in the United States and Territories, by State and paralytic status, 1956 [1]

Region and State	Paralytic	Nonparalytic	Total [2]	Region and State	Paralytic	Nonparalytic	Total [2]
Northeast	**463**	**573**	**1,471**	**Southeast**	**940**	**795**	**1,971**
Maine	16	4	22	Delaware	10	18	28
New Hampshire	[3]	1	3	Maryland	89	22	111
Vermont	12	9	21	Dist. of Columbia	7	4	11
Massachusetts	44	50	111	Virginia	150	84	236
Rhode Island	1	[3]	9	West Virginia	60	47	114
Connecticut	28	55	86	North Carolina	178	144	336
New York	289	357	797	South Carolina	38	56	114
New Jersey	73	97	212	Georgia	77	66	197
Pennsylvania	[3]	[3]	210	Florida	103	170	365
				Kentucky	75	88	200
North Central	**2,123**	**2,403**	**5,856**	Tennessee	91	55	156
Ohio	165	146	628	Alabama	62	41	103
Indiana	179	125	433				
Illinois	964	630	1,843	**South Central**	**1,516**	**928**	**2,723**
Michigan	283	323	683	Mississippi	154	66	296
Wisconsin	199	189	554	Arkansas	144	77	221
Minnesota	66	139	205	Louisiana	427	195	622
Iowa	44	526	629	Oklahoma	67	30	224
Missouri	117	133	421	Texas	724	560	1,360
North Dakota	7	27	40				
South Dakota	3	13	38	**Southwest**	**1,484**	**1,035**	**2,814**
Nebraska	42	110	195	Colorado	86	67	162
Kansas	54	42	187	New Mexico	36	21	84
				Arizona	73	54	130
Northwest	**242**	**184**	**565**	Utah	[3]	[3]	224
Montana	32	15	55	Nevada	1	2	35
Wyoming	20	12	37	California	1,288	891	2,179
Idaho	43	21	110				
Washington	71	60	190	Total	6,768	5,918	15,400
Oregon	76	76	173				
				Alaska	7	2	12
				Hawaii	51	17	68
				Puerto Rico	45	6	51

[1] Provisional data reported to the National Office of Vital Statistics, Public Health Service.

[2] Includes cases reported with paralytic status unspecified (2,714 for the United States).

[3] None of the cases reported so designated.

- Vaccine reactions are rare.
- Neurological illnesses following vaccination include 2 cases of encephalitis, 5 cases of myelitis, 1 sudden death (no definite cause found on autopsy), and a small number of minor self-limited illnesses such as meningismus, febrile convulsions, and labyrinthitis. It appears unlikely that these illnesses are related to prior vaccination, but further information must be collected, particularly on cases of encephalitis and myelitis, before any final evaluation can be reached.
- Local or generalized mild allergic reactions (such as urticaria) may occur in rare instances following vaccination. Two reports have been received of more severe dermatological illnesses following vaccination, but their relationship to prior inoculation appears questionable.

Table 3. Percentage distribution of paralytic and nonparalytic poliomyelitis cases, by age group, 1952, 1955, 1956 [1]

Age group (years)	Percent distribution					
	Paralytic			Nonparalytic		
	1952	1955	1956	1952	1955	1956
0–4	29	32	39	21	19	20
5–9	24	21	16	31	29	27
10–14	13	12	11	16	17	16
15 and over	33	34	34	31	34	37
Total	100	100	100	100	100	100

[1] Based on provisional data, including 21,971 cases from 22 States in 1952, 18,378 cases from 34 States in 1955, and 10,286 cases from 45 States in 1956. Cases in which paralytic status was not stated are excluded.

• There have been no reports of nephritis or other renal disease following vaccination.

• There have been no reports of hematological illnesses in which vaccine was considered to play a role.

Vaccine Effectiveness

Evaluation of vaccine effectiveness includes an analysis of the age distribution of cases by vaccination and paralytic status, a special study of the frequency of paralysis in hospitalized patients according to number of vaccine doses, special studies in three States comparing attack rates among vaccinated and unvaccinated children, and an analysis of reports of cases among persons who had received three doses of vaccine.

Age Distribution Analysis

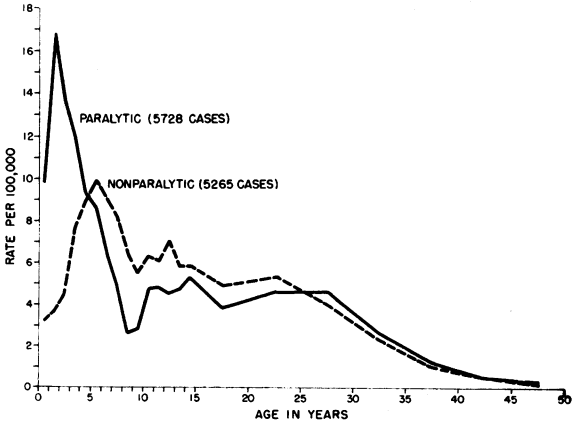
During 1956, 44 States, the District of Columbia, and 3 Territories cooperated with the Poliomyelitis Surveillance Unit in an age distribution study. They reported to the unit the age, paralytic status, and vaccination history of all verified cases of poliomyelitis. These cases represent about three-fourths of all cases reported for the Nation. Data by age and paralytic status for 1955 and 1952, collected from a number of States in a similar study conducted in 1955, were available for comparison. Three separate qualitative measures of vaccine effectiveness are apparent from a preliminary analysis of the 1956 data in relation to the earlier data.

A definite shift was observed in the age distribution of paralytic cases. In comparison with data for 1955 and 1952, 1956 data showed an increase in relative incidence in the under-5-year age group, with a compensatory decrease in the relative incidence in the 5-to-9-year age group (table 3). No significant change was apparent in the age distribution of nonparalytic cases. This shift in age distribution of paralytic cases may be associated with the known fact that the young school age group was more extensively vaccinated than the preschool age group. In particular, children in the first and second grades of school in the spring of 1955, who were largely 8- and-9-year-olds during the past poliomyelitis season, were thoroughly vaccinated in school clinics sponsored by the National Foundation for Infantile Paralysis. The reduction in paralytic incidence in this group is apparent in figure 4, which shows age-specific attack rates by single years of age. The paralytic age curve peaks sharply at age 1 and decreases rapidly through age 6. Except for the trough at ages 8 and 9, the age-specific rates remain relatively constant from ages 7 to 30, decreasing gradually thereafter.

Although the overall frequency of paralysis by age groups was similar to that reported in 1955 (table 4), the frequency of paralysis among reported cases in the under-20-year age group was markedly lower among vaccinated cases, 34 percent, than among unvaccinated cases, 60 percent (table 5). This difference supports the conclusion that vaccination prevented some paralysis.

Among the paralytic cases reported during the midsummer season in the under-20-year age group, 21 percent were vaccinated (table 6). This figure may be compared with estimates of the proportion of the population under 20 that had received one or more doses by that time. A conservative figure is 50 percent. The difference points to a vaccine effectiveness of the order of 75 percent against paralytic poliomyelitis. (Seventy-nine percent of the paralytic cases occurring in the unvaccinated population and 21 percent occurring in the same number of vaccinated persons indicate a reduction in the vaccinated rate compared with the unvac-

Figure 4. Age distribution of poliomyelitis in the United States, 1956.



NOTE: Preliminary and incomplete data from 45 States.

Table 4. Frequency of paralysis in poliomyelitis cases, by age group, 1952, 1955, and 1956 [1]

Age group (years)	Percent paralytic		
	1952	1955	1956
0–4	69	65	69
5–9	56	44	40
10–14	57	44	43
15 and over	64	53	50
All ages	62	52	52

[1] Based on provisional data, including 21,971 cases from 22 States in 1952, 18,378 cases from 34 States in 1955, and 10,286 cases from 45 States in 1956. Cases in which paralytic status was not specified are excluded.

cinated rate proportional to the reduction from 79 to 21. This reduction is $(79-21)\div 79=73$ percent.) A similar computation may be made for the 5-to-9-year age group. It is estimated that at least two-thirds of this age group had been vaccinated, while one-third of the paralytic cases in the age group were vaccinated (fig. 5 and table 6). This difference again leads to a crude estimate of 75 percent effectiveness against paralytic poliomyelitis. (Two-thirds of the paralytic cases occurring in the unvaccinated population and one-third in twice as many vaccinated persons indicate a reduction in the vaccinated rate compared with the unvaccinated rate proportional to the reduction from $\frac{2}{3}$ to $\frac{1}{3}\div 2$. This reduction is $(\frac{4}{6}-\frac{1}{6})\div \frac{4}{6}=75$ percent.)

NFIP Study

The National Foundation for Infantile Paralysis conducted a study of hospitalized poliomyelitis patients during the height of the 1956 poliomyelitis season. Reports were received on 3,198 patients with acute cases in 408 hospitals in 48 States. When these patients were grouped according to number of vaccine doses received prior to onset, the frequency of paralysis declined progressively from 59 percent among unvaccinated patients to 23 percent among those who had received three doses (fig. 6). Thus, this study provides additional evidence of the effectiveness of the vaccine in 1956.

Special Studies in Three States

During the past year California, Florida, and Minnesota were able to follow the distribution of vaccine in sufficient detail to obtain reasonable estimates of vaccinated populations by age groups. Current State estimates of the total population in the age groups studied were used. After estimation of the size of the vaccinated group, the size of the unvaccinated group was obtained by subtraction. Attempts at direct measurement of vaccine effectiveness during 1956 in preventing paralytic poliomyelitis were thus possible in these States.

Several factors introduce sources of potential bias in these analyses. Case reports were received through morbidity reporting systems of widely varying accuracy. Total population

Table 5. Frequency of paralysis in poliomyelitis cases, by age and vaccination history, 1956 [1]

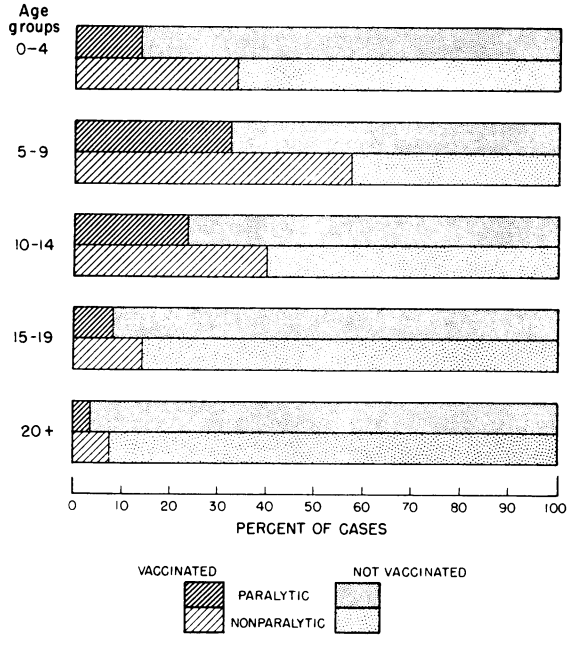
Age group (years)	Vaccinated [2]		Not vaccinated		Total	
	Total cases	Percent paralytic	Total cases	Percent paralytic	Total cases	Percent paralytic
0–4	610	46. 7	2, 471	73. 9	3, 081	68. 5
5–9	1, 026	27. 2	1, 144	50. 9	2, 170	39. 7
10–14	461	30. 8	939	49. 1	1, 400	43. 1
15–19	103	31. 1	783	45. 8	886	44. 1
0–19	2, 200	33. 5	5, 337	60. 5	7, 537	52. 6
20 and over	152	33. 6	2, 597	53. 0	2, 749	51. 9
Total	2, 352	33. 5	7, 934	58. 0	10, 286	52. 4

[1] Based on preliminary and incomplete data from 45 States. A total of 1,107 cases, representing 10 percent of the total reported cases in these States, are excluded because one or more of the following were reported as unknown: paralytic status, vaccination history, month of onset, or age.

[2] Cases with one or more inoculations prior to onset are classified as vaccinated.

figures and vaccine usage figures (particularly for commercial supplies of vaccine) were necessarily estimates. Variations in geographic and age-specific vaccination rates and attack rates could not be completely accounted for. Risk of exposure was assumed to be equal in the two populations and constant throughout the study period. Although attempts have been made to minimize the effect of these sources of error, interpretations of the results must necessarily be guarded.

Figure 5. Percentage of paralytic and nonparalytic poliomyelitis cases reported as vaccinated and as not vaccinated, 1956.



NOTE: Preliminary and incomplete data from 45 States.

Estimates of effectiveness according to numbers of doses are not reported here. Thus, the estimates represent overall effectiveness of varying composites of 1, 2, and 3 doses of vaccine and should be interpreted accordingly.

Preliminary results of these studies are summarized in table 7. In each State, paralytic attack rates were significantly lower among vaccinated persons than among unvaccinated persons. Each of these independent studies indicates an overall vaccine effectiveness in preventing paralytic poliomyelitis of about 75 percent. These results are in general agreement with results of similar analyses conducted in 1955 (*1*).

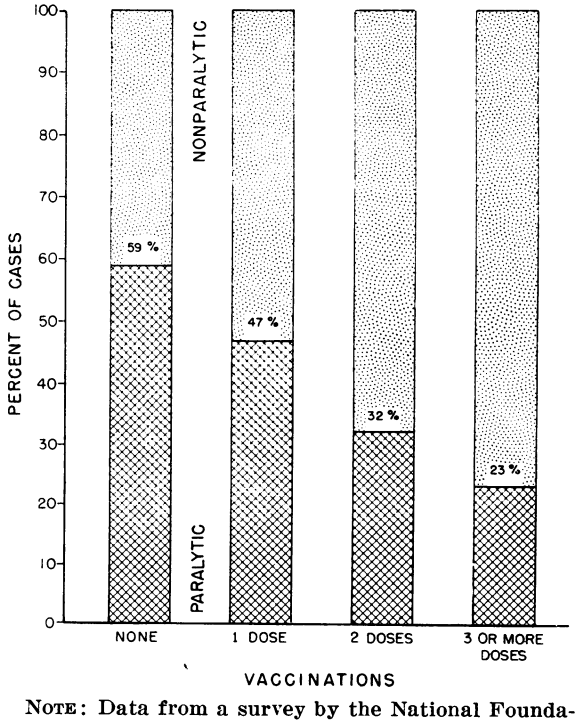
Triple-Vaccinated Cases

In September 1956 a national registry was established in the Poliomyelitis Surveillance Unit for reports of poliomyelitis among individuals who have received three doses of vaccine. Recorded data include clinical, epidemiological, and laboratory information. Residual paralysis is being documented by convalescent muscle gradings or supplemental descriptions from attending physicians. In a few cases followup information has resulted in a revised diagnosis or changed paralytic or vaccination status. Triple-vaccinated cases reported through January 18, 1957, have received the following classifications:

	Number of cases
Nonparalytic	154
Paralytic	34
Confirmed, with residual paralysis	19
Under investigation	9
Revoked (not paralytic or not vaccinated)	6
Total cases	188

More stringent criteria have been applied in establishing these triple-vaccinated cases as par-

Figure 6. Frequency of paralysis in hospitalized cases of poliomyelitis, by vaccination history, Aug. 15–Sept. 30, 1956.



NOTE: Data from a survey by the National Foundation for Infantile Paralysis.

Table 6. Percentage of poliomyelitis cases reported as vaccinated, by paralytic status, age group, and month of onset, 1956 [1]

Age group (years)	January–June		July–November		Total	
	Total cases	Percent vaccinated [2]	Total cases	Percent vaccinated [2]	Total cases	Percent vaccinated [2]
	Paralytic cases					
0–4	694	8.4	1,417	16.0	2,111	13.5
5–9	257	29.6	604	33.6	861	32.4
10–14	172	15.1	431	26.9	603	23.5
15–19	91	2.2	300	10.0	391	8.2
0–19	1,214	13.3	2,752	20.9	3,966	18.7
20 and over	353	1.4	1,074	4.3	1,427	3.6
All ages	1,567	10.7	3,826	16.3	5,393	14.6
	Nonparalytic cases					
0–4	178	24.7	792	35.5	970	33.5
5–9	246	50.0	1,063	58.7	1,309	57.1
10–14	139	28.8	658	42.4	797	40.0
15–19	84	7.1	411	15.8	495	14.3
0–19	647	32.9	2,924	42.7	3,571	40.9
20 and over	252	1.6	1,070	9.1	1,322	7.6
All ages	899	24.1	3,994	33.7	4,893	31.9

[1] Based on preliminary and incomplete data from 45 States. A total of 1,107 cases, representing 10 percent of the total reported cases in these States, are excluded because one or more of the following were reported as unknown: paralytic status, vaccination history, month of onset, or age.

[2] Cases with one or more inoculations prior to onset are classified as vaccinated.

alytic poliomyelitis than are used in the routine reporting of the disease. For this reason it is not possible to compare directly these triple-vaccinated cases with other groups of paralytic cases, vaccinated or unvaccinated.

Laboratory specimens have been collected on 16 of the 19 confirmed paralytic cases. Poliovirus was isolated from 7, other virus from 2, and no virus from 3. Final laboratory results have not yet been submitted on the four remaining cases. Thus, to date, seven triple-vaccinated paralytic cases have received laboratory confirmation.

Three deaths from poliomyelitis have been reported in triple-vaccinated persons. One case was established as bulbar poliomyelitis, but a recheck of vaccination records revealed that the child had never been vaccinated. A second case was clinically consistent with poliomyelitis, but pathological review revealed instead the anatomic findings of acute disseminated encephalomyelitis. The one remaining fatal case occurred in a 5-year-old boy who died the day after onset of fever and within 30 minutes of hospitalization. Findings of an autopsy performed without examination of the brain or spinal cord were reported as compatible with poliomyelitis. This is the only fatal case now being carried in the registry.

Vaccine Under Epidemic Conditions

There has been particular interest in evaluation of the effectiveness and possible dangers of administering poliomyelitis vaccine during epidemics. In particular, based on previous studies with diphtheria and pertussis antigens, it had been feared that the vaccine might "provoke" the development of subsequent paralysis in persons infected at the time of, or shortly after, vaccination. The first study of this problem was conducted during a small outbreak of poliomyelitis among U. S. Navy personnel and

dependents in Hawaii in late 1955 (*2*). This analysis revealed no evidence of a "provoking" effect.

In 1956 the largest concentration of poliomyelitis occurred in Chicago, where more than 1,100 cases were reported. This outbreak presented an unusual opportunity for the study of mass vaccination under epidemic conditions. In collaboration with the Chicago Board of Health, the Cook County Health Department, the Illinois Department of Public Health, the division of services for crippled children of the University of Illinois, and the National Foundation for Infantile Paralysis, the Public Health Service undertook an epidemiological, clinical, and laboratory study of poliomyelitis cases occurring in Chicago and suburban Cook County.

Table 7. Results of three studies of vaccine effectiveness, 1956

Item	California,[1] June 1–Aug. 31 (ages 0–14 years)	Florida,[2] June 1–Aug. 31 (ages 0–19 years)	Minnesota,[3] Aug. 1–Oct. 31 (ages 0–19 years)
Estimated person-months at risk (hundred thousands):			
Vaccinated	96. 66	4. 35	20. 86
Not vaccinated	99. 66	8. 19	13. 06
Paralytic cases:			
Vaccinated	111	5	8
Not vaccinated	398	38	24
Paralytic rates (per 100,000 population):			
Vaccinated	1. 2	1. 1	. 4
Not vaccinated	4. 0	4. 6	1. 8
Estimated effectiveness (percent)[4]	71	75	79
Lower limit of effectiveness (percent)[5]	66	44	57

[1] Data reported by Drs. A. C. Hollister, Jr., and R. L. Magoffin, bureau of acute communicable diseases, California Department of Public Health, and by Drs. G. L. Caplan and M. L. Wyman, epidemic intelligence service officers, assigned to the California Department of Public Health.

[2] Data reported by Drs. J. O. Bond and W. T. Sowder, Florida State Board of Health.

[3] Data reported by Drs. H. Kleinman and C. S. Fleming, division of disease control and prevention, Minnesota Department of Health.

[4] Difference between unvaccinated and vaccinated rates, divided by unvaccinated rate. Vaccine effectiveness thus expresses the percent reduction in the vaccinated attack rate as compared with the unvaccinated rate. Presumably, this reduction is due largely to the vaccine.

[5] Calculated at the 95 percent confidence level according to the method used by Francis and associates (reference 3, appendix, p. 62).

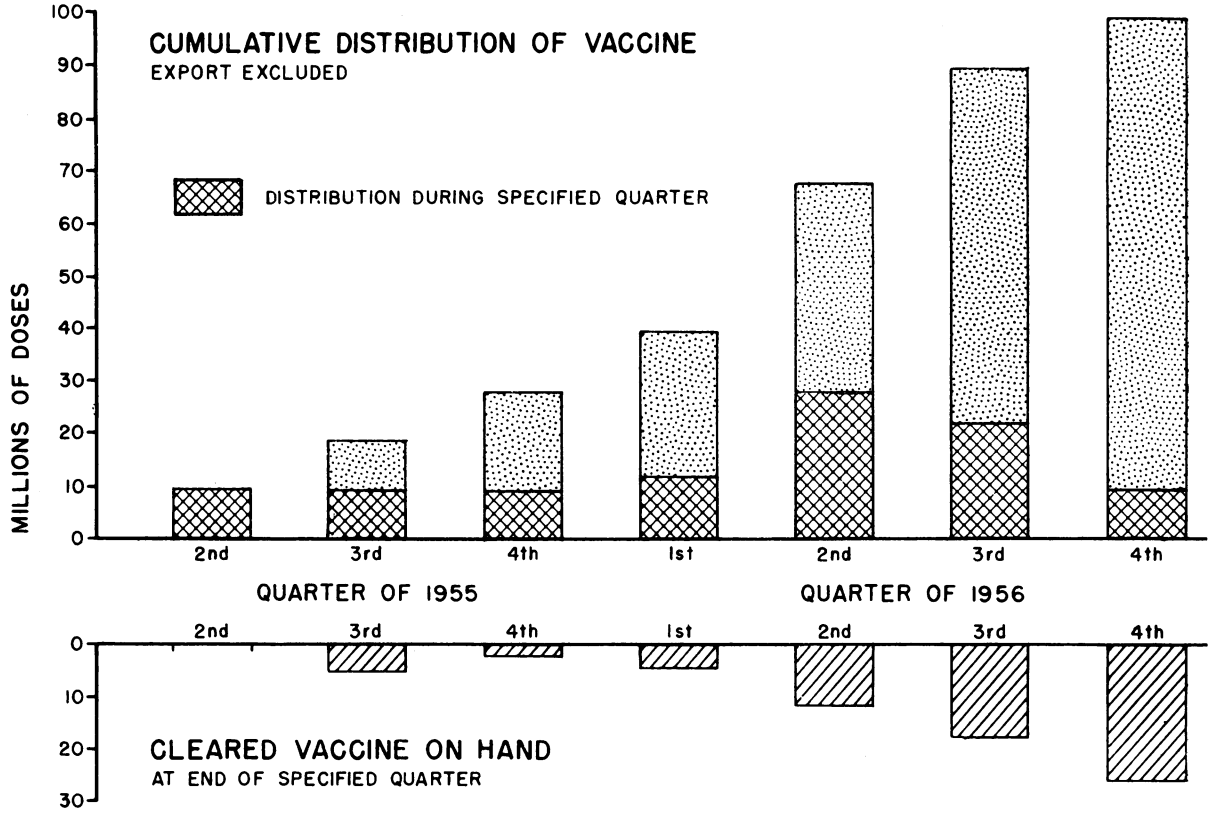
Preliminary analysis of epidemiological data showed patterns differing markedly from previous years, particularly the last previous epidemic year of 1952. In 1952 cases were scattered quite evenly throughout the city. In 1956 early cases were also scattered widely, indicating a general dissemination of the virus. However, as the outbreak progressed, high rates developed only in those areas of the city characterized by a particularly dense population, a low socioeconomic status, and a high proportion of nonwhites. In 1952 cases among nonwhites constituted 14 percent of the total cases as compared with 61 percent in 1956. In 1956 there was a shift in the age distribution of cases toward the preschool age group. This shift was particularly marked for the cases in the white population.

Preliminary analysis of clinical and laboratory data has revealed no unusual findings. About 60 percent of the cases were reported as paralytic. Stool specimens obtained from a large number of cases and examined by the laboratories of the Illinois Department of Public Health yielded predominantly type 1 poliovirus.

In late July 1956, during a period of rapidly rising incidence, the Chicago Board of Health initiated a large-scale mass vaccination program. Through the cooperative efforts of medical and other organizations in the city, more than 1.5 million doses were administered in less than 2 months. However, this program began too late to demonstrate any dramatic effect upon the epidemic curve.

In an attempt to delineate any possible "provoking" effect following this large number of inoculations, a preliminary analysis of about 400 vaccinated cases (including more than 300 cases occurring within 30 days of inoculation) was made. This analysis revealed no evidence that prior inoculation influenced the localization of subsequent paralysis. Among paralytic cases, there were 11 with initial involvement of the inoculated limb, 11 with initial involvement of the opposite uninoculated limb, and 13 with involvement of both the inoculated limb and the opposite uninoculated limb.

Figure 7. Distribution of poliomyelitis vaccine, 1955–56.



NOTE: Data from Poliomyelitis Vaccine Activity, Bureau of State Services, Public Health Service.

A more complete presentation of findings in Chicago during 1956 will be published under the direction of Dr. Herman N. Bundesen, president, Chicago Board of Health.

Vaccine Distribution

During 1955 and 1956 a total of 98.2 million doses of poliomyelitis vaccine were distributed for domestic use, including 27.7 million doses from April through December 1955 and 70.5 million doses in 1956. An additional 6.5 million doses were exported during recent months of 1956. Through the end of 1956, a cumulative total of 130.6 million doses of vaccine (net cubic centimeters of bottled vaccine) had been released after clearance by the National Institutes of Health, Public Health Service, leaving a balance of 25.9 million doses on hand at the close of the year.

Distribution of vaccine by calendar quarters is presented in figure 7. Quarterly shipments of vaccine reached a peak in the second quarter of 1956, when 27.8 million doses were distributed. Shipments declined progressively during the last two quarters of 1956, lagging considerably behind vaccine releases. This progressive accumulation of vaccine available for use is also shown in figure 7.

Of the 98.2 million doses distributed domestically, 13.7 million were purchased by the National Foundation for Infantile Paralysis, primarily for vaccination of first- and second-grade school children in 1955, 53.5 million were distributed through public agencies, and 31.0 million were distributed through normal drug channels. Specific usage by age group and by first, second, or third inoculation for only a part of this vaccine is known.

There are between 60 and 65 million persons under 20 years of age in the United States and Territories. Just over half enough vaccine has now been distributed to complete three inoculations for each individual in this group. More than 100 million doses in addition would be required to complete vaccination of the population aged 20 to 40.

Discussion and Summary

The experience in the United States during 1956 shows that poliomyelitis vaccine has been safe and effective. Several hundred cases of poliomyelitis occurred shortly after inoculation, but this many vaccine-associated cases could easily be coincidental in view of the more than 70 million doses of vaccine that were administered. The vaccine-associated cases had all the characteristics of naturally occurring poliomyelitis. There was slight, if any, evidence of untoward reactions from the vaccine. While the concepts of absolute vaccine safety or total absence of a provoking effect of inoculation are not scientifically tenable, the epidemiological observations during 1956 indicated that any such hypothetical effects occurred at a frequency of less than one per million inoculations.

During 1956 the effectiveness of the vaccine could not be evaluated in well-controlled field studies, such as Francis conducted in 1954 (*3*), or in large-scale comparison-group studies such as were made in 1955 (*1*). It was necessary to depend largely upon qualitative studies and upon orderly epidemiological inferences based on careful observation and analysis. A number of independent studies consistently point to a level of effectiveness in preventing paralytic cases of 75 percent, with a large proportion of the vaccinated population having received less than the recommended course of three doses. The effectiveness of three doses, properly spaced, has not yet been fully evaluated, but the occurrence of several well-confirmed triple-vaccinated paralytic cases shows it to be less than 100 percent.

Considerable evidence has accumulated to show that the present vaccine is less effective in preventing nonparalytic cases and in controlling the spread of inapparent infection. Two published studies (*4, 5*), as well as unpublished work of Lipson, Carver, and Robbins and of Davis and Melnick, have shown that vaccinated children in household contact with poliomyelitis cases can readily become infected, although, again, the effect of three doses has not yet been fully evaluated. Thus the primary effect of vaccine appears to be the prevention of invasion of the central nervous system and thereby the prevention of paralysis. This limitation on the effectiveness of the vaccine may be associated with the evidence that poliovirus did spread rather extensively in various populations during 1956, not only in Chicago, but in Louisiana, Utah, Idaho, California, and elsewhere. In spite of relatively widespread, but incomplete, vaccination, these populations experienced high incidence of disease, particularly among preschool children in all socioeconomic groups.

The immediate public health implication of the experience in 1956 is that substantially higher levels of immunity must be achieved among all elements of the population.

REFERENCES

(*1*) Langmuir, A. D., Nathanson, N., and Hall, W. J.: The surveillance of poliomyelitis in the United States in 1955. Am. J. Pub. Health 46: 75–88, January 1956.

(*2*) Poos, R. S., and Nathanson, N.: Use of poliomyelitis vaccine under epidemic conditions: Report of outbreak of poliomyelitis among naval personnel and dependents in Hawaii. J. A. M. A. 162: 85–92, September 1956.

(*3*) Francis, T., Jr., Korns, R. F., Voight, B. S., Boisen, M., Hemphill, F. M., Napier, J A., and Tolchinsky, E.: Evaluation of 1954 field trials of poliomyelitis vaccine: Summary report. Am. J. Pub. Health, Vol. 45, May 1955. pt. 2.

(*4*) Lipson, M. A., Robbins, F. O., and Woods, W. A.: The influence of vaccination upon intestinal infection of family contacts of poliomyelitis patients. Abstracts of the forty-eighth annual meeting of the American Society for Clinical Investigation. J. Clin. Investigation 35: 722, June 1956.

(*5*) Gelfand, H. M., Fox, J. P., and LeBlanc, D. R.: Observations on natural poliovirus infections in immunized children. Am. J. Pub. Health 47: 421–431, April 1957.