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POLIOMYELITIS

The attached paper on the "Effectiveness of the Vaccine" by Dr. Alexander D. Langmuir was prepared for the Scientific Symposium on Poliomyelitis Vaccine under the auspices of the School of Public Health, University of Michigan, Ann Arbor, Michigan, January 6, 1959. Dr. Langmuir has kindly made this Report available to the Sub-Committee.

EFFECTIVENESS OF THE VACCINE*

A REPORT ON THE SURVEILLANCE OF POLIOMYELITIS

IN THE UNITED STATES - 1955 TO 1958

by

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INTRODUCTION

Rarely have the time, the place and the occasion conspired more appropriately for a progress report on the conquest of poliomyelitis. Since April 1955, four polio seasons have passed. Accomplishments have been substantial indeed, but much remains to be done.

The main accomplishments to date include:

(1) Since April 1955, over 230 million doses of polio vaccine have been shipped for domestic use. This is enough to provide the full course of three doses for more than 70 million persons. Since May of 1955 no untoward incident involving the safety of this vaccine has been reported.

(2) A comprehensive system of nationwide surveillance of poliomyelitis and polio-like diseases has been established. No large national control programme has ever been guided so closely by current epidemiological facts.

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(3) The occurrence of polio cases has been greatly reduced. The former upward trend in the nation has been reversed. The epidemiological pattern of the cases now occurring is distinctly different from the characteristic behavior of the disease in the prevaccine period.

(4) The evidence is impressive for the degree and duration of vaccine effectiveness.

The remaining problems to be solved include:

(1) Over 50 million people under 40 years of age remain unvaccinated or incompletely vaccinated. The job of achieving full immunization of the 110 million people in this population age group is only half complete. Progress toward this goal was distressingly slow in 1958.

(2) The recent rapid decline in national incidence of polio has been halted. In fact, the latest figures for 1958 show an ominous rise over 1957.

(3) Severe epidemics have occurred in 1958. The tragedy is that these were avoidable.

The overriding conclusion to be drawn from the past four years' experience is that the programme has been soundly laid. All the evidence confirms the results of the Francis Report on the effectiveness and mode of action of polio vaccine. The scientific knowledge, and the technical "know-how", are at hand to complete the job. The conquest of paralytic poliomyelitis is in sight through universal immunization of the population under 40 years of age. With proper organization and persistent effort this can be achieved.

INCIDENCE

Let us look at the record. Figure 1 shows the annual attack rates for the total reported cases since 1910. You will see the unique epidemic year of 1916, then the relatively low and variable incidence until the early 1940's, the sharp upward trend from 1942 to the record epidemic year in 1952, the moderately high rates in 1953 and 1954, and the steep downward trend of the past four years. In 1958, however, the smooth decline was halted. The preliminary total of reported cases will be about 6,000, at least 500 cases higher than the final total for 1957, an increase of almost 10 per cent.

The story for paralytic cases is more disturbing. In 1958 a higher proportion of reported cases was paralytic. The excess of paralytic cases this year over last will probably be 1,000, an increase of 40 per cent. This is a danger signal that calls for careful re-appraisal of the whole national programme.

Where polio occurred in 1958 is shown in Figure 2. In seven States attack rates for paralytic cases exceeded 3.0 per 100,000. In former years

such rates would hardly have been considered to be at the epidemic level. A major epidemic occurred in Detroit, Michigan; also epidemics of considerable severity occurred in the metropolitan area of northern New Jersey and in the Virginia-West Virginia Mountains. Small localized outbreaks appeared in San Antonio, Texas and in a Blackfeet Indian Reservation in Montana. These will be described in greater detail later.

AGE DISTRIBUTION

The age distribution of poliomyelitis (Figure 3) has always been an epidemiological characteristic of prime interest and importance. Studying the changes of the past four years has contributed significantly in guiding the control programme and in revealing the effectiveness of the vaccine. Figure 3 shows age specific attack rates for paralytic cases for these years. The comparable data for 1952 are also shown. Rates for individual years of age are charted up to age 14. A different number of States is included for each year and the data for 1958 are not yet complete. Therefore the absolute level of the rates shown is not relevant but the proportionate changes by age are most revealing.

The curve for 1952 is typical of a prevaccine year. The attack rate under one year of age was moderately low, reflecting the near absence of the disease under 6 months of age. This immunity of infants is ascribed to transplacental transfer of antibodies from the mother. From 1 to 8 years of age there is a sustained high incidence followed by a slow but steady decline to age 14. Unfortunately, adequate national data for paralytic cases among older teenagers and adults for 1952 are not available.

In 1955, the first year of the polio vaccine, the shape of the age distribution curve was essentially similar to that of 1952, except for a sharp drop in attack rates among 7 and 8 year old children with a relative rise in rates among 9 and 10 year olds, continuing into the 11 to 14 year age group. These remarkably low rates among the 7 and 8 year olds can be associated with the fact that the limited supplies of vaccine in 1955 were restricted largely to the immunization of first and second grade school children. Approximately 75 per cent of the pupils in these two grades received either one or two of vaccine in the spring of 1955. These children were largely 7 and 8 years old and clearly a definite degree of protection was conferred even by the partial course of immunization they then received. Watch the polio experience of this cohort of the first and best immunized children as they grow up over the next three years.

In 1956 an abrupt change in the age pattern of polio was observed. The peak incidence occurred at one year of age after which there was a steep decline

in attack rates with each increasing year of age. The lowest rates occurred in the well immunized cohort now 8 and 9 years old. A plateau of moderate attack rates continues from age 10 to 30. The greatest relative decline occurred in the age groups from 2 to 14 years; the least decline occurred under 2 years of age and among adults.

In 1957 and 1958 the general character of the age specific curves is similar to that of 1956. The peak incidence is still among the one year olds. The lowest rates are still clearly discernible in the well immunized cohort, 9 and 10 years old in 1957 and the 10 and 11 years old in 1958. There has been a relatively greater decline in attack rates among adults from 1956 to 1957 than there was from 1955 to 1956. A slight further relative decline occurred among adults in 1958.

These changes can be associated with the selective utilization of polio vaccine over this period of three-and-a-half years. The continuing low attack rates in the cohort of children that were 7 and 8 years demonstrate not only a substantial protective effect of the vaccine against paralytic disease but also show that its duration of immunity continues over at least a three year period. To be sure, in 1956 the low rates can be explained by assuming that this cohort was receiving third or booster shots while their colleagues in upper and lower grades were receiving only their primary first and second inoculations. Thus the original group still would be somewhat better immunized. In 1957 and 1958, however, with the widening span of immunization and with long enough time elapsing for a complete series for all school children, one would expect an equalizing of the immunity status. If the duration of effectiveness of the vaccine was short, a matter of only one to two years, the immunity of the original cohort should wane. Since lower rates continue in this cohort, persistence of immunity is evident.

The changes in age specific attack rates in other ages also reflects the effectiveness of the vaccine. By the summer of 1956 substantial amounts of vaccine had been available for children in all primary school grades and for pregnant women. Intensive immunization of preschool children was under way in many but not all areas of the country. Teenagers, high school students, and adults had received only a little. It can be seen that the greatest relative decreases in 1956 occurred among the best vaccinated age groups.

In January 1957 an intensive national campaign of polio vaccination was inaugurated with the sponsorship of the American Medical Association, the National Foundation, the Public Health Service, and many local health and medical agencies. The response was overwhelming. A backlog of more than 25 million doses of vaccine, then in storage, was exhausted in a six-week period.

New production was in great demand. During the six-month period from January through June 1957, over 60 million doses were shipped, and during the next three months, an additional 24 million doses were distributed. The marked reduction in incidence of paralytic disease that affected all age groups in 1957 presumably reflects at least in part the extent of the immunization achieved.

From October 1957 to the present time, the demand for polio vaccine has fallen to a disturbingly low level. During 1958 less than 50 million doses have been distributed within the country. Recognizing that the number of new births per year now exceeds 4 million, the maintenance level of vaccine distribution just to immunize the new babies with a full course of three inoculations will approximate 12 to 15 million doses. Thus the excess over this minimum maintenance level during 1958 was only about 36 million doses, or enough to fully protect 12 million persons. Since more than 50 million persons remain in the unvaccinated or incompletely vaccinated group, a large number of susceptibles still exists to support future epidemics.

These susceptibles are not uniformly spread over the country, but rather are concentrated in certain areas in well defined pockets, which might be called "soft-spots". Some of these "soft-spots" were the source of epidemics in 1958; others undoubtedly exist as potential foci of future epidemics. They primarily include groups of preschool children in crowded urban areas. Also certain specially isolated, ethnically distinct groups have remained unvaccinated for economic, religious or other reasons. Sound planning for the conquest of polio must include the identification of all of these "soft-spots" and then the designing of suitable local programmes to correct the deficiencies.

OCCURRENCE IN VACCINATED PERSONS

Further incidence of vaccine effectiveness is shown by a study of the history of immunization among reported cases of paralytic and nonparalytic diseases. All States have joined with the Communicable Disease Centre in the collaborative polio surveillance programme. In 1958 individual case reports have been submitted and tabulated so far on about two-thirds of the total. The data for the paralytic cases are shown in Table 1. Note that slightly more than 50 per cent of the cases occurred in the 0 to 4 age group and more than two-thirds developed in unvaccinated children. The proportion of cases appearing in children with a history of 3 or more inoculations, the so-called triply vaccinated cases, is shown in the right-hand column. Interpretation of these percentages requires comparison with similar figures for the non-paralytic cases and for the total population. These are shown in Table 2. The data for triply vaccinated paralytic cases are drawn from the preceding table. The data for nonparalytic cases come from similar surveillance reports from the States. The data for the total population are generously provided

by Dr. Monroe Sirken of the National Office of Vital Statistics and are based on a random sample survey of 35,000 families conducted by the Bureau of the Census in September 1958.

Note that on the basis of this survey, only 45.3 per cent of preschool children in the country were triply vaccinated. Approximately three-fourths of the 5 to 9 and 10 to 14 year age groups received three or more doses. The proportion falls to 52.4 for older teenagers and to only 26.2 per cent for adults from 20 to 39.

The effectiveness of the vaccine against paralytic polio is demonstrated by comparing for each age group the percentages in the left-hand column with those in the right-hand column. For each group without exception the proportion of paralytic cases that were triply vaccinated is markedly lower than the comparable proportion in the random population sample. If the vaccine were ineffective, one would expect the proportions to be similar. The degree of the difference permits a rough calculation of effectiveness. This comes out to be in the range of 75 per cent.

It has been widely accepted that polio vaccine is ineffective against the nonparalytic form of the disease. The data in Table 2 tend to refute this concept. Note that for all age groups up to 39, the proportions of non-paralytic cases (middle column) are lower than those for the total population. These consistent differences indicate a definite protective effect of the vaccine. The degree of the protection conferred cannot be measured because it is known that many of the cases reported as nonparalytic polio are actually aseptic meningitis due to ECHO and Coxsackie viruses and to other causes. Vaccine cannot be expected to protect against these diseases. If these erroneous diagnoses could be eliminated from these figures, the proportions shown in the central column would be lowered considerably and might well approach those in the left-hand column. It is clear that polio vaccine has a protective effect against the nonparalytic form of poliovirus infection.

EPIDEMICS IN 1958

The three main polio epidemics in 1958 vividly illustrate the localized character of such outbreaks in the postvaccine period. They help to pinpoint the problems that remain to be solved.

Polio epidemics have always tended to be somewhat spotty and unpredictable, but in the prevaccine period, it was usual for epidemics to extend over rather wide areas embracing a series of contiguous countries or even whole states or groups of states. When a polio epidemic involved a larger city, it was almost always widely and quite evenly spread among all sections. It was no respecter of political or socioeconomic boundaries. Outbreaks often tended to appear

first in crowded slum areas, to spread rapidly within these groups, and to involve predominantly the preschool age groups. In the more comfortable peripheral and suburban areas of a city the epidemics usually developed more slowly and involved more school age children and even some adults. But when the attack rates for the whole epidemic were determined, they usually were about equal for all socioeconomic levels of the area, and sometimes the rates were higher in the upper economic classes.

In 1958 this characteristic pattern has radically changed. Epidemics have been sharply concentrated to specifically defined ethnic groups and to distinct geographic areas. Within single cities, attack rates have been dramatically different among various sections and socioeconomic classes. The outstanding and consistent feature of this new pattern is that epidemics have selected only poorly vaccinated populations.

The data on the Detroit epidemic have been generously made available by Dr. Joseph G. Molner, Commissioner of Health, and Dr. Albert E. Heustis, State Health Officer.

This epidemic was the most severe one in the nation. A total of 625 cases were reported, of which 50 per cent were paralytic. This was the second most severe epidemic in the history of the city. As will be reported in greater detail by Dr. Gordon Brown, Type I poliovirus was predominant, but some cases of Type III virus also occurred. The epidemic began late in July, rose to a peak by mid-September and declined through October. Sixty per cent of the cases were under five years of age. Only five per cent of the cases had received three doses of vaccine.

As shown in Figure 4, the paralytic cases were concentrated in the central sections of the city. Those are the areas of poorest socioeconomic conditions, greatest crowding, and most poverty and also the lowest level of polio immunization. Only a slight scattering of cases occurred in the peripheral areas where the middle and upper class homes are located and where the population is relatively well immunized against polio. When attack rates are calculated for the central areas of the city alone, epidemic levels are found that exceed all previous records in the city. These rates were 18 times higher than the rates in the peripheral areas.

The nonparalytic cases also tended somewhat to concentrate in the centre of the city, but many more cases occurred throughout the peripheral areas too. As will be reported by Dr. Brown, most of these nonparalytic cases were not caused by polioviruses and should not be counted as part of the polio epidemic. Thus the distribution of the paralytic cases more properly described the character of the polio epidemic in Detroit. The epidemic was limited to specific geographic areas and concentrated among essentially unvaccinated preschool children.

The data for the northern New Jersey epidemic are generously provided by Dr. Daniel Bergsma and Dr. William Dougherty of the State Health Department. A total of 136 cases were reported from the three metropolitan counties of Essex, Hudson, and Bergen, comprising a little over 2 million population. Seventy-five per cent of the cases were paralytic. Both Type I and Type III virus were prevalent. The epidemic began early in July, peaked in early September and essentially ended by mid-October. Forty-six per cent of the paralytic cases were under five years of age. Only 4 per cent had received 3 doses of vaccine.

The distribution of the cases is shown in Figure 5. The paralytic cases are limited primarily to the densely crowded urban areas in the eastern part of Essex and Hudson County. Only scattered cases appeared in the more suburban areas of western Essex and Bergen County. The nonparalytic cases, however, were more widely distributed. As in Detroit the poliomyelitis epidemic selected unvaccinated preschool children in well defined geographic locations.

The data for the Virginia-West Virginia outbreak have been compiled from Surveillance Reports submitted by the States and made available by Dr. Mack I. Shanholtz and Dr. N.H. Dyer, State Health Officers.

The epidemic embraced 29 counties in the Appalachian Mountain soft coal mining regions. A total of 202 cases were reported of which three-fourths were paralytic. The epidemic occurred in typical mid-summer fashion. Fifty-seven per cent of the paralytic cases were under five years of age. Only 6.2 per cent had received three doses of vaccine. The distribution of the cases is shown in Figure 6. This epidemic was much more extensive in its distribution, but still was largely confined to economically depressed soft coal mining communities. While many of these are small and might be classed as rural, the actual living conditions in the narrow mountain valleys of this area with dense crowding and poor housing, have many similarities to urban slums. Vaccination for poliomyelitis had been largely ignored.

The pattern of the outbreaks in San Antonio, Texas and the Blackfeet Indian Reservation in Montana were very similar in their localization to special groups of unvaccinated children.

DISCUSSION

The ominous rise of 40 per cent in the incidence of paralytic polio in 1958 over 1957 calls for all of us who are concerned with the conquest of polio to pause a moment, to reappraise our situation and to redirect our efforts. Where have we failed? Is the problem due to lack of sufficient scientific knowledge? Has some new mechanism appeared in the biological balance between polioviruses and man that permits the viruses to survive and

plague us? Is new basic research the only hope of a solution? Or is our failure a failure of application? Have we sufficiently applied our existing knowledge to achieve its full potential?

A categorical answer can be given. We have failed in application. While research still has much to offer in the development of new or better vaccines, and in furthering our incomplete knowledge of the epidemiology of poliovirus infection, the evidence is clear that present knowledge and present tools properly applied will achieve substantial reduction of paralytic poliomyelitis.

The distribution of 230 million doses of vaccine without untoward incident attests to its safety. The changing age distribution of paralytic cases in relation to vaccine usage, and the occurrence of paralytic disease largely among unvaccinated persons attest to its effectiveness. The continued low attack rates among the cohort of children who received preferential immunization in 1955 shows a gratifying duration in the immunity conferred by the vaccine.

Without question, 1958 was a higher incidence year than 1957. Polioviruses spread more widely and caused significantly more paralytic disease in spite of the fact that some 30 million doses of vaccine were distributed between October 1957 and July 1958, thus increasing considerably the immunity level of the nation. In spite of this, the higher rates in 1958 cannot be explained on the basis of waning immunity. No evidence supports such a conclusion. Rather, all evidence points to the limitation of the paralytic form of the disease largely to unvaccinated or only partially vaccinated persons. Epidemics in 1958 were limited sharply to specific groups among the least vaccinated populations in the country.

It must be concluded that 1957 was a low-incidence year due both to wide spread use of vaccine and to natural causes as yet too poorly understood. Conversely 1958 must have been a high incidence year due to other poorly understood causes. In both years the incidence was remarkably lower than that which would have been expected had no vaccine been used.

Epidemiological knowledge does not permit a forecast of whether 1959 would, from natural causes alone, be a higher or a lower incidence year than 1957 or 1958. We can predict with confidence, however, that with intensification of our efforts to the achievement of substantially higher levels of immunity in the total population, the actual incidence of paralytic disease again will progressively decline. When we eliminate the "soft-spots", the areas of unvaccinated or poorly vaccinated populations, particularly in our cities and other crowded urban type communities, epidemics of the type observed in 1958 will disappear.

These immunization goals can only be reached by well planned local organization. We no longer can solely rely on broad scale publicity programmes, or clinics in schools, or on the parents of all unvaccinated children spontaneously to seek out the service. Public health officials have learned from the diphtheria experience of previous decades and from all types of personal health programmes that these must be organized on a local neighbourhood basis.

Careful surveys should be conducted in every city of the country. These can be performed in a quick and practical fashion and serve to delineate the location and extent of the unimmunized areas. Once identified, it is the classic function of the public health department to coordinate and guide the local programme. The help of all official and voluntary health and medical agencies and local citizens groups is needed to achieve success. In executing the programme there is no approach as effective as the personal face to face interview on a door to door basis. The necessary services must be available within the customary reach and within the economic capability of each family.

Once the "soft-spots" have been eliminated by specially designed programmes, and once a high level of immunity has been reached, the job is not finished. A continuing persistent programme of adequate immunization of all newborn infants during their first year of life is essential. In the past three years peak incidence has occurred between 1 and 2 years of age. If the immunization programme lags for only a short time a group of susceptible children will rapidly accumulate and constitute a potential epidemic threat.

In the final conquest of poliomyelitis, new and unanticipated problems may still be encountered. Such has been the rule in the conquest of other diseases. From the progress over the last four years, however, and from an analysis of the problems of 1958, no technical barrier can now be visualized that will hinder substantial further progress. With the achievement of essentially universal immunization of the population under 40 years of age, we should achieve essential elimination of paralytic poliomyelitis. This goal is well within reach.

TABLE 1

POLIOMYELITIS - UNITED STATES - 1958
Reported Paralytic Cases by Age and Vaccination Status

Age Group	0	Number of Inoculations				Total	Per Cent Triply Vaccinated
		1	2	3	4		
0 - 4	749	99	71	86	3	1,008	8.8
5 - 9	203	33	38	65	2	341	19.6
10 - 14	57	10	14	38	3	122	33.6
15 - 19	71	8	12	17	-	108	15.7
20 - 39	272	21	16	30	2	341	9.4
40 +	28	2	-	1	-	31	3.2
Total	1,380	173	151	237	10	1,951	12.7

Preliminary data tabulated through December 29, 1958, based on individual surveillance reports submitted by all States.

TABLE 2

POLIOMYELITIS - UNITED STATES - 1958

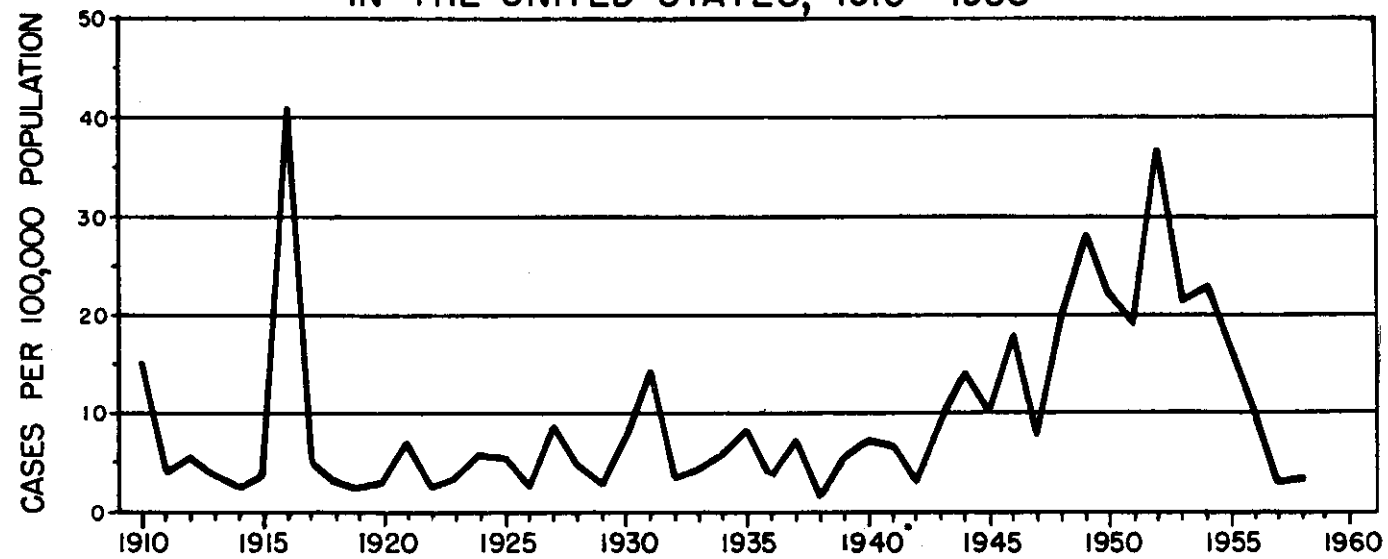
Proportions of Reported Cases having 3 or More Vaccine
Inoculations by Age, Compared with a Random Sample of
the Total Population

<u>Age Group</u>	Proportion "Triply Vaccinated"		
	<u>Paralytic Cases⁽¹⁾</u>	<u>Nonparalytic Cases</u>	<u>Total Population⁽²⁾</u>
0 - 4	8.8	25.1	45.3
5 - 9	19.6	46.7	73.5
10 - 14	33.6	50.8	74.9
15 - 19	15.7	45.6	52.4
20 - 39	9.4	17.9	26.2
40 +	3.2	10.3	6.7
Total	12.7	35.5	36.3

(1) Preliminary data tabulated through December 29, 1958.

(2) Derived from a National Survey in August 1958 through courtesy of
Dr. Monroe G. Sirken, National Office of Vital Statistics.

FIGURE 1
ANNUAL POLIOMYELITIS INCIDENCE RATE
IN THE UNITED STATES, 1910-1958



DHEW - PHS - BSS - CDC ATLANTA, GA.

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FIGURE 3
PARALYTIC POLIOMYELITIS — UNITED STATES
AGE SPECIFIC ATTACK RATES: 1952, 1955-1958

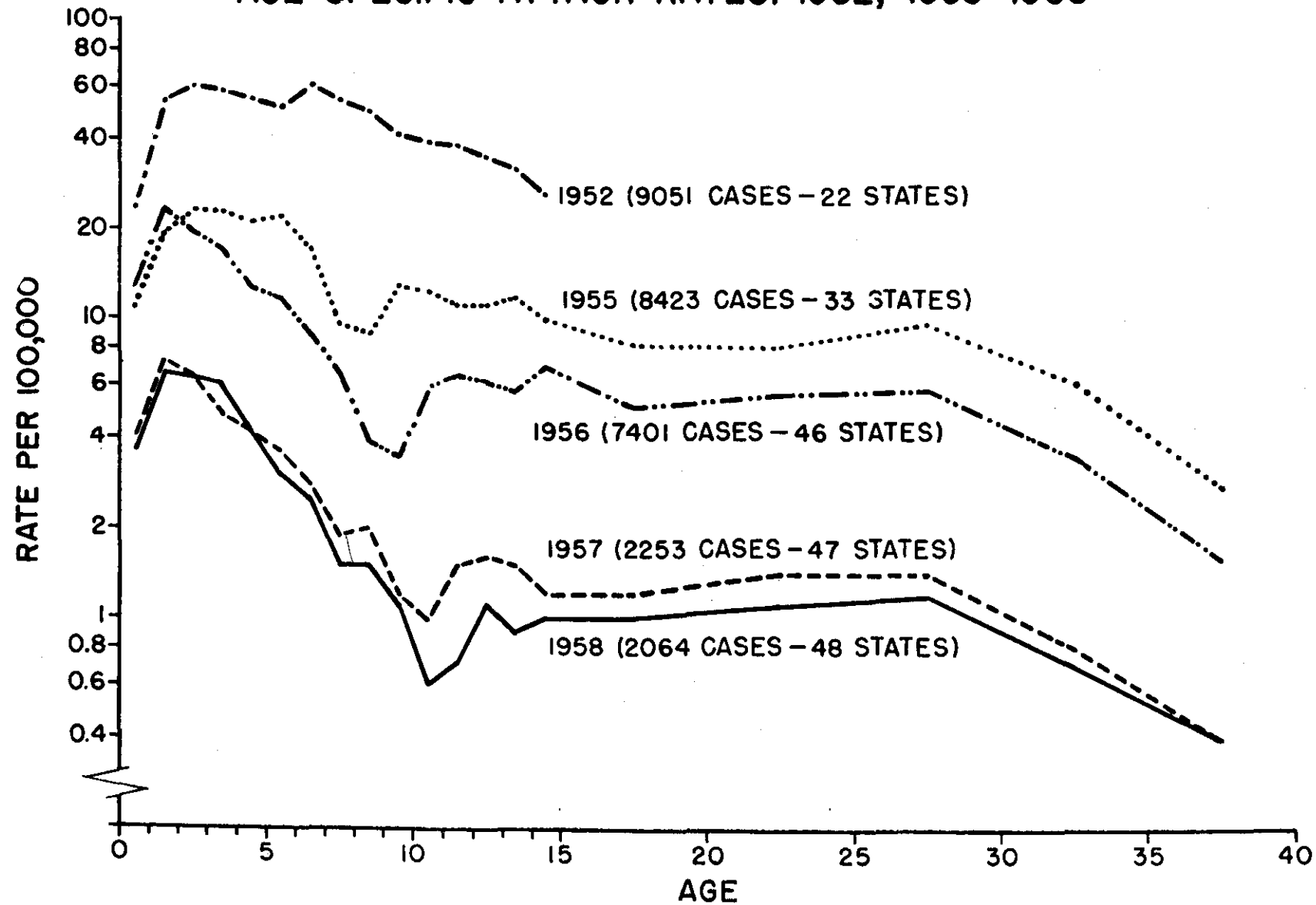


FIGURE 4
POLIOMYELITIS - DETROIT, 1958

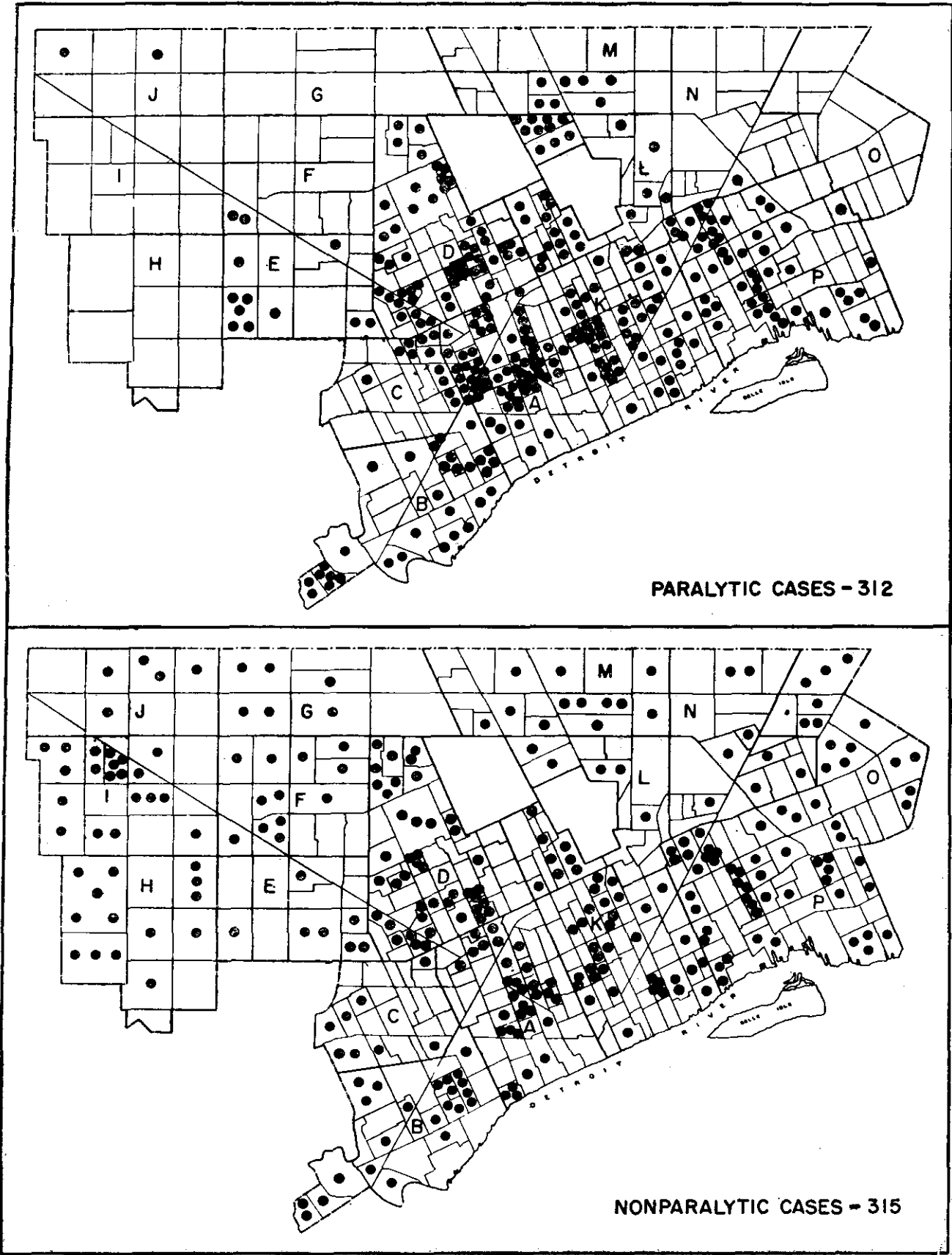


FIGURE 5
POLIOMYELITIS—NEW JERSEY—1958
Essex, Hudson and Bergen Counties

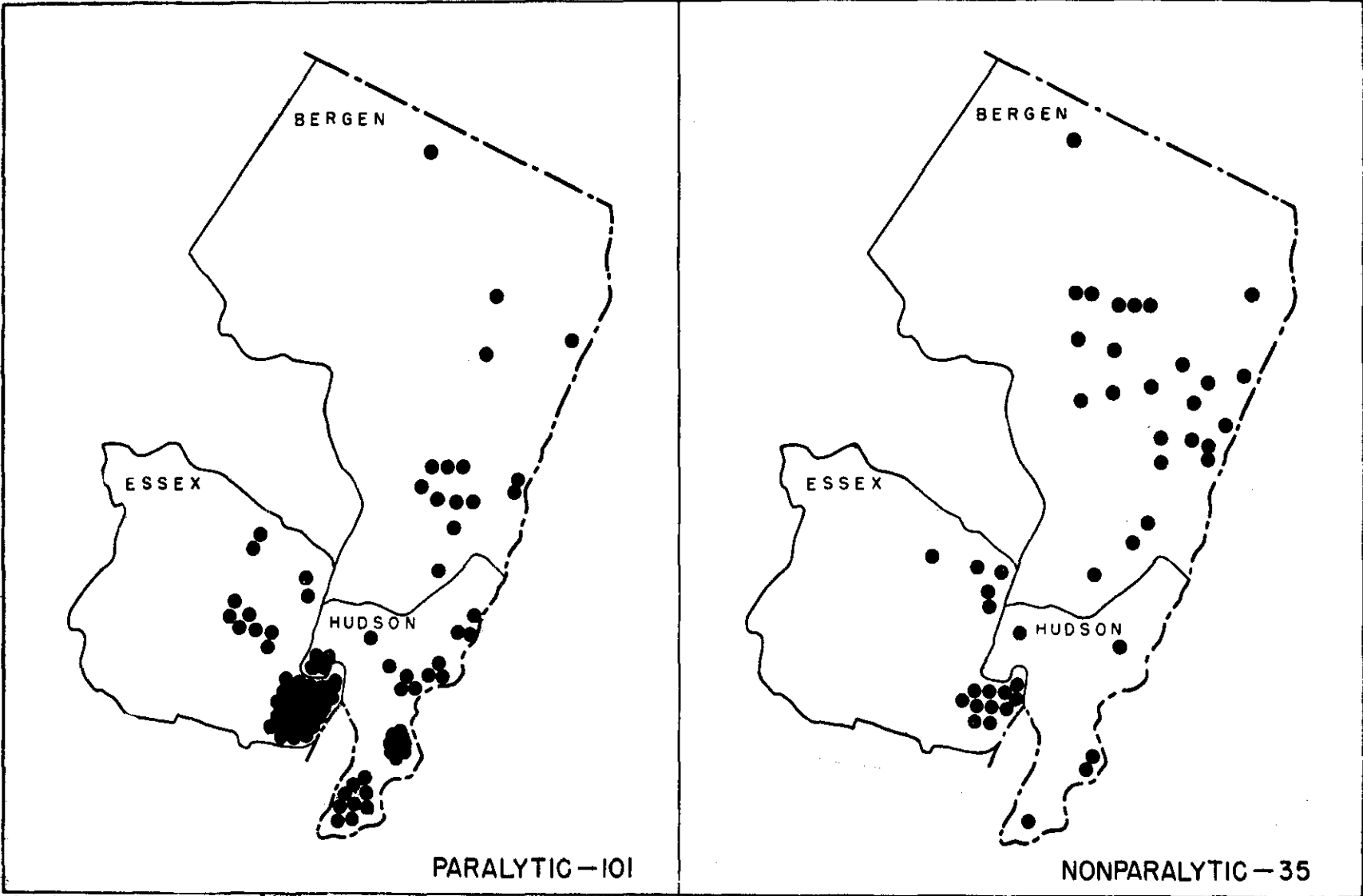


FIGURE 6
POLIOMYELITIS - VIRGINIA, WEST VIRGINIA - 1958
PARALYTIC CASES

