Seattle-King County, Wash., 1959

Poliomyelitis in an Immunized Community

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COMMUNITY outbreaks of poliomyelitis have been reported frequently in the literature, particularly during the last 30 years. Yet new epidemiological patterns, as observed in the outbreak of 113 paralytic cases of poliomyelitis in Seattle-King County, Wash., in 1959, recall the wisdom of Benjamin Rush (*1*): "Above all, record the epidemics of every season. Such records, if published, will be useful to foreigners and a treasure to posterity."

Background

Since 1901 when the first poliomyelitis case (a death) was documented in Seattle, 2,904 cases and 294 deaths have been recorded. Although faulty diagnosis, incomplete reporting, and poor records detract somewhat from the accuracy of the statistical record, especially during the earlier decades, the data do permit the conclusion that 1910, with 88 cases and 15 deaths, was the first year that epidemic poliomyelitis was recognized in this community and that the greatest morbidity and mortality rates (40 cases and 6.3 deaths per 100,000 population) occurred in 1924. Poliomyelitis occurred with a natural periodicity of about 3 to 4 years during the 40-year interval 1908 to 1948. Reported morbidity was then sustained at the high level of about 20 cases per 100,000 population for 7 years (table 1, fig. 1). Beginning in 1955, a rapid decline occurred, with sustained low morbidity rates and no deaths during 1956, 1957, and 1958. Then during 1959, a sharp increase occurred which produced morbidity and mortality rates approaching those observed during the 1950–54 period.

The sustained decrease in poliomyelitis cases from 1955 through 1958 coincided with intensive Salk vaccination activity (table 2), which had reached a high proportion of the population by May 1959. A survey of the vaccination status of school children in May 1959, revealed that about 93 percent of all elementary school children had received at least three doses of Salk vaccine. In the poorest school districts, however, only about 46 percent of kindergarten children were so protected on entry to school, despite the availability of free vaccination through well-child clinics (table 3). More publicity was therefore generated concerning the routine availability of free vaccination from a daily central clinic and outlying weekly well-child clinics. In addition, a mobile, door-to-door vaccination program was conducted during June in the High Point public housing project, with a followup clinic in July. By this means 966 injections of Salk vaccine and 250 DTP injections were administered to the 1,200 families residing in this housing project. Even after this campaign many residents of the housing project remained unvaccinated because of fear of vaccination or absence from the area during the canvass.

An approximate measure of the vaccination status of the community was derived as a by-product of a summer-long study of swimming-

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associated illnesses. Among 1,000 families who visited six beaches in the metropolitan area during August 1959 and who could be contacted again by telephone (therefore derived from the 80 percent of households which have telephones), the poliomyelitis vaccination status of persons under 40 years of age was as follows: 13 percent, no vaccination; 3 percent, one shot; 7 percent, two shots; 65 percent, three shots; and 12 percent, four or more shots. In addition, from three spot surveys in the lowest socioeconomic neighborhoods and from knowledge of vaccinations performed during recent years, it was known that the least immunized members of the community were (*a*) residents of low-income housing areas, including Negroes, (*b*) preschool children and adults, especially adult males, and (*c*) firm believers in Christian Science.

Despite these vaccination defects no substantial increase in poliomyelitis during 1959 was anticipated, because of low incidence during 1956–58 and because the community was significantly better immunized than during those years. Therefore, when it became apparent during August that despite such protection Seattle was experiencing a substantial outbreak of poliomyelitis, a thorough epidemiological investigation was begun.

Method of Investigation

Detailed information concerning each patient was obtained by means of home and hospital visits and telephone calls and from physicians' and clinical records. As usual, age, sex, race, occupation, onset date, symptoms, clinical findings, and vaccination and pregnancy status for each patient were ascertained. Also, extensive data concerning each patient's exposure to theoretical common sources such as food (especially fruit and vegetables), water (including 1959 swimming experience), physicians, injections, dentists, insects, travel, and ill persons were obtained. In addition, the tonsillectomy status of each patient and the religious preference of each patient and his family were ascertained, and each patient's residence was visited and photographed to provide more exact knowledge of housing and socioeconomic status. Later, the paralytic status of each patient alive 60 days after onset of illness was ascertained. Experienced investigators assisted in collecting data, and whenever necessary, patients and physicians were queried repeatedly.

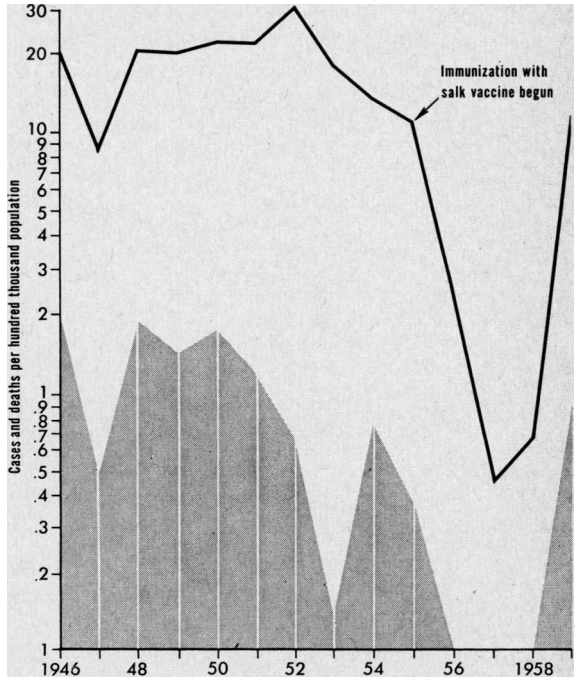
As usual, all death certificates received by the

Table 1. Poliomyelitis occurrence by year, Seattle-King County, Wash., 1946–59

Year	Cases		Deaths		Fatality rate (percent)
	Number	Rate[1]	Number	Rate[1]	
1946	133	19.8	13	1.93	9.77
1947	54	8.3	3	.46	5.56
1948	141	20.6	13	1.90	9.22
1949	143	20.2	10	1.42	6.99
1950	165	22.5	13	1.77	7.88
1951	166	22.1	9	1.20	5.42
1952	236	30.9	5	.65	2.12
1953	144	18.4	1	.13	.69
1954	[2] 108	13.6	6	.75	5.56
1955	[2] 90	11.1	3	.37	3.33
1956	[2] 22	2.6	0	0	0
1957	[2] 4	.5	0	0	0
1958	[2] 6	.7	0	0	0
1959	[2] 113	12.8	8	.90	7.08

[1] Per 100,000 population.
[2] Paralytic cases only.

Figure 1. Poliomyelitis cases and deaths per 100,000 population, Seattle-King County, Wash., 1946–59



health department were inspected, and followup investigations were made whenever information given on a certificate suggested that such investigation might significantly improve understanding of the contribution of infection toward that death.

Attending physicians and the hospitals were requested to submit stool specimens from patients for specific diagnosis. These were examined by the laboratory of either the Seattle-King County or the Washington State Health Department, or both, by standard methods using monkey kidney cells.

Findings

Epidemiological analysis is based on the 113 paralytic poliomyelitis cases recorded during 1959. Cases were accepted as paralytic poliomyelitis if characteristic weakness of one or more muscles developed in association with fever and stiff neck. The diagnosis of almost all cases was corroborated either by spinal fluid findings or detection of poliovirus in stool, or both. Spinal fluid, which was examined in 98 cases, revealed more than 10 leucocytes per cubic millimeter in 91, and more than 40 milligram percent protein in 56. Type 1 poliovirus was isolated from 65 (82 percent) of the 79 patients from whom stool specimens were examined. No isolations of types 2 and 3 poliovirus were obtained from the patients. ECHO 9 enterovirus was isolated from 2 of these 79 patients, once in addition to type 1 poliovirus and once alone. In addition, type 1 poliovirus was isolated from stool specimens in 4 of the 88 nonparalytic aseptic meningitis cases recorded during the year, which were specifically identified as mumps (14 cases), ECHO 9 (7 cases), ECHO 6 (2 cases), Coxsackie B2 (4 cases), Coxsackie B5 (3 cases), and Coxsackie A9 (4 cases).

One death, attributed to "cerebral vascular accident," cause unknown, by the attending physician, is included as bulbar poliomyelitis because of characteristic clinical and epidemiological findings. The details of this case are reported to permit the reader to evaluate the propriety of including it as a poliomyelitis death as well as to document the value of routine inspection of death certificates, with ap-

Table 2. Poliomyelitis vaccination, Seattle-King County, Wash., 1955–59

Year	Type of program	Number doses
1955	First and second grade children, by NFIP, health department, private physician volunteers	47, 473
	Children, by private physicians, office practice	[1] 45, 000
1956	Persons less than 20 years of age or pregnant, in mass public district clinics by health department (Federal and local tax monies)	81, 391
	Children and young adults, by private physicians, office practice	[1] 395, 000
1957	Persons less than 20 years of age or pregnant, through perennial central clinic and complete, free, two-round school program for kindergarten through 12th grade in all public and private schools, by health department (Federal and local tax monies)	153, 042
	All ages, by private physician volunteers, in the three-round, mass, free, fire-station program sponsored by the King County Medical Society, United Good Neighbors, and NFIP (vaccine purchased with UGN and NFIP funds)	315, 000
	All ages, especially less than 40 years of age, by private physicians, office practice	[1] 105, 000
1958	Persons under 20 years of age or pregnant, through perennial free clinic, annual school program (as above) and well child clinics, by health department (local tax monies)	64, 440
	All ages, especially less than 40 years of age, by private physicians, office practice	[1] 110, 000
1959	Persons under 50 years of age, through perennial free clinic, annual school program (as above), well child clinics, and special clinics, by health department (local tax monies)	97, 457
	All ages, by private physicians, office practice	[1] 95, 000
Total		1, 508, 803

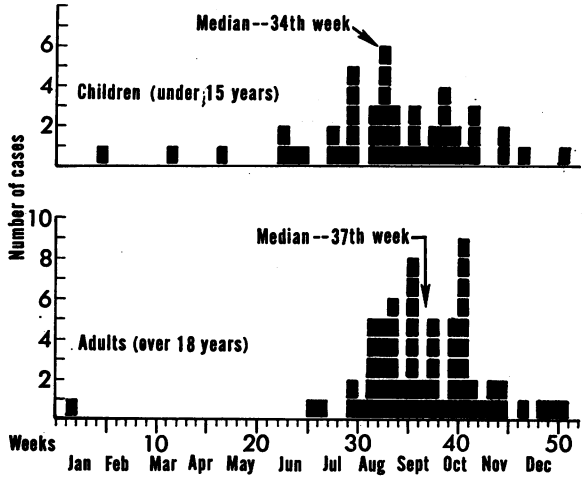
[1] Estimates from vaccine shipments.

NOTE: Estimated 1959 population: Under 20 years of age—323,000; 20–39 years of age—215,000; total—885,000.

propriate investigation, as a useful casefinding technique.

Interest was aroused by the medical certification that a 24-year-old construction worker, resident of a public housing project, had died on August 15, 1959, of "cerebral vascular accident (minutes)," due to "cause unknown," due to "influenza—5 days." Review of his hospital record revealed that he became ill on August 7, with sore throat, headache, and fever. He was admitted by wheelchair to a nonteaching hospital on August 11, under care of a surgeon, complaining of severe headache, pain in the neck, back, and abdomen, weakness of his legs, and inability to void. Examination revealed sluggish but equal reflexes, distended and tympanitic abdomen, and weakness of his legs. His temperature was 100°; white blood count, 9,850, with normal differential. His urine was normal. The initial impression was "influenza," and treatment was begun with penicillin, achromycin, steam inhalator, "pneumonia jacket," Seconal, Solu B, 5 cc. I.V., and "diathermy to lower back daily." The following day the nurse noted that he was "unable to move right leg" and needed help to turn over. He developed cough, copious sputum, and difficulty in breathing, which resulted in short, gasping respirations and oxygen treatment. It was noted that breath sounds were markedly diminished at both bases, but chest X-rays were negative on August 12 and August 15. He remained lucid and his sensation continued normal. His temperature became approximately normal after 2 days in the hospital, but he died 4 days after admission, shortly after complaining of inability to breathe, and despite additional treatment with Demerol, terpin hydrate, sodium luminol, Thorazine, oxygen, pharyngeal suctioning, and steam. No autopsy or additional laboratory studies were performed, and no mention of poliomyelitis (for which he had not been vaccinated) was made in the record.

Figure 2. Paralytic poliomyelitis cases by week of onset, Seattle-King County, Wash., 1959



Distribution by Week of Onset

The outbreak began in June and ceased in December. The epidemic curve for children reached its peak in the 34th week and that for adults, in the 36th and 41st weeks (fig. 2). Median week of onset for children preceded the median week for adults by about 3 weeks. Seasonal distribution of cases was similar to that usually observed in this area.

Table 3. Poliomyelitis vaccination status of school children in selected elementary schools, before and after 1959 school vaccination program, Seattle, Wash.[1]

Area	Percent in each category							
	No injections		At least 1 injection		At least 2 injections		At least 3 injections	
	Before	After	Before	After	Before	After	Before	After
Wedgewood:[2]								
Kindergarten	5.23	3.27	94.8	96.7	94.1	96.1	91.5	94.1
All grades	2.85	2.50	97.2	97.5	96.0	97.4	94.8	97.0
Beacon Hill:[3]								
Kindergarten	11.8	2.78	88.2	97.2	88.2	93.8	78.5	86.1
All grades	4.54	1.55	95.5	98.4	94.0	97.7	86.3	95.4
High Point:[4]								
Kindergarten	29.8	17.8	70.2	82.2	69.3	77.8	45.8	70.2
All grades	18.2	11.6	81.8	88.4	78.4	86.2	69.2	79.6

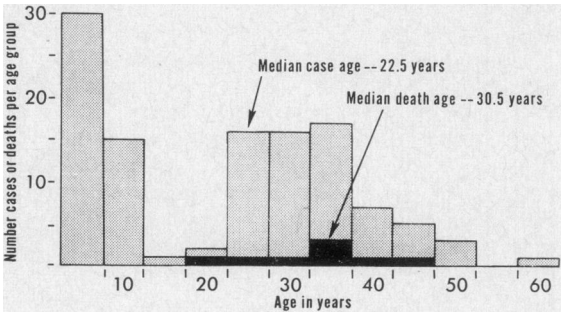
[1] Figures compiled after review of each child's school record and query of parents if record incomplete. The 1959 vaccination program was conducted January through March; survey in May.
[2] Upper socioeconomic, all white.
[3] Middle socioeconomic, 48 percent white, 44 percent oriental, 4.4 percent Negro, 3.1 percent other.
[4] Lowest socioeconomic, 76 percent white, 18 percent Negro, 6 percent other.

Geographic and Socioeconomic Distribution

Contrasting markedly with years before vaccination became available, when poliomyelitis cases were generally distributed in Seattle-King County but with a tendency toward greater incidence in the better residential areas, during 1959 there was an easily noticeable concentration of cases in and around public housing projects in southwest Seattle-King County. Fourteen (12.4 percent) of the 113 paralytic cases were residents of public housing projects (which are mostly located in southwest Seattle). Four cases (two in unvaccinated men, one in an unvaccinated 15-month-old child, and one in a 2-year-old child with three doses of vaccine) occurred during August and September among the 1,200 families living in the High Point public housing project. The southwest Seattle focus was particularly noticeable during June, July, and August. Later the geographic distribution became more diffuse. However, upper socioeconomic residential areas, such as Magnolia, Laurelhurst, Windermere, Mercer Island, and Bellevue, remained strikingly free of cases.

Wage earners in families of patients worked at a great variety of occupations, most of which were in the "blue collar" class, such as aircraft production, construction, machinist, television repair, automobile wrecker, judo instructor, bartender, boatbuilder, and truckdriver. Six were unemployed. There were several salesmen, accountants, and engineers, but no physicians, lawyers, teachers, ministers, dentists, or college students.

Figure 3. Age distribution of paralytic poliomyelitis cases and deaths, Seattle-King County, Wash., 1959



Age and Sex Distribution

The 1959 poliomyelitis outbreak was remarkable particularly because an unusually large proportion of patients were adults (table 4, fig. 3). Sixty-seven (59 percent) of the 113 were adults (including two 19-year-olds, both of whom were parents). To my knowledge the median ages for cases (22.5 years) and deaths (30.5 years) are the highest ever recorded in a major community outbreak of poliomyelitis. Patients ranged in age from 9 months to 57 years, and those who died, from 19 to 42 years. Seventy-two (64 percent) of the 113 patients and five (62 percent) of those who died were male. Sixty-six percent of the patients 20 years or over were men, contrasting with years before vaccination became available, for example 1954, when men comprised only 33 percent of such cases. The sex reversal of adult cases was at least partially due to the decrease in cases

Table 4. Paralytic poliomyelitis cases, by age and sex, Seattle-King County, Wash., 1954–59

Age group (years)	1954		1955		1956		1957		1958		1959	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
All ages	53	55	46	44	14	8	4	0	4	2	72	41
0–4	11	7	12	6	4	2	2	0	1	0	19	11
5–9	17	8	10	6	3	1	0	0	1	0	8	7
10–14	6	6	5	4	2	1	0	0	0	1	1	0
15–19	3	2	3	2	0	1	0	0	0	1	1	1
20–29	9	23	8	15	2	3	1	0	0	0	22	10
30–39	5	8	8	11	3	0	1	0	2	0	16	8
40 and over	2	1	0	0	0	0	0	0	0	0	5	4
Median age	14. 6		17. 6		11. 5		12. 5		15. 5		22. 5	
Age range	3 wk.–50 yr.		5 mo.–39 yr.		16 mo.–34 yr.		18 mo.–32 yr.		18 mo.–38 yr.		9 mo.–57 yr.	

among pregnant women (table 5). Ten cases in pregnancy were recorded in 1954 and again in 1955. Then, in association with intensive vaccination of pregnant women, no cases were recorded in this group during 1956, 1957, and 1958. During 1959 only two cases in pregnant women (both unvaccinated, one a Christian Scientist) were recorded.

Ninety-six (85 percent) of the 113 patients were either preschool children (30 patients) or lived in households with preschool children (66 patients). Included in this latter group was the oldest patient, age 57, who lived with an 18-month-old granddaughter. Fifteen patients (13 percent) were either school children (7 patients) or lived in households with school children but without preschool children (8 patients). Only two adults (ages 21 and 49 years) had not had regular household contact with children during the month prior to onset; both had had sporadic contact with preschool children.

Distribution by Vaccination Status

Seventy-three (65 percent) of the 113 patients had received no Salk vaccine prior to onset of their disease; 11 (9.7 percent) had received one shot; 9 (8.0 percent), two shots; 19 (16.8 percent), three shots; and 1, four shots (table 6).

Table 6. Age and vaccination status of paralytic poliomyelitis cases, Seattle-King County, Wash., 1959

Age group (years)	Number of Salk vaccine injections					Total
	0	1	2	3	4	
0–4	17	4	2	6	1	30
5–9	4	1	3	7	0	15
10–14	0	1	0	0	0	1
15–19	1	1	0	0	0	2
20–29	27	1	1	3	0	32
30–39	17	3	2	2	0	24
40 and over	7	0	1	1	0	9
Total	73	11	9	19	1	113

For the 19 triply vaccinated patients the median time interval from third injection to onset of disease was 17 months, and the range was from 6 to 25 months. The interval appeared to be especially a function of community vaccination activities, for example, the mass programs in 1957 (table 2), rather than waning immunity. That adequate immunity is not particularly a function of time after vaccination was further indicated by the single quadruply vaccinated patient, a 3-year-old boy in whom paralytic disease from type 1 poliovirus developed 5 weeks after he received the last of four optimumly spaced shots.

Table 5. Epidemiological data on paralytic poliomyelitis cases, Seattle-King County, Wash., 1954–59

Characteristic	1954	1955	1956	1957	1958	1959
Total cases	108	90	22	4	6	113
Pregnancy cases	10	10	0	0	0	2
Injections of Salk vaccine:						
0	108	89	15	0	2	73
1	0	0	3	1	2	11
2	0	1	4	3	1	9
3	0	0	0	0	1	19
4	0	0	0	0	0	1
Race:						
White	104	88	22	4	6	105
Negro	1	1	0	0	0	7
Other	3	1	0	0	0	1
Type of paralysis:						
Bulbar	44	44	8	0	3	54
Nonbulbar	64	46	14	4	3	59
Public housing resident [1]	3	2	1	0	0	14
Cases per 100,000 public housing residents [1]	15. 6	10. 4	5. 2	0	0	73. 1

[1] Current public housing project population of 19,141 persons, including 8,680 children, is similar to population at risk throughout 1954–59 period.

Poliomyelitis began 7, 8, and 26 days after initial injections in three patients. Each had received vaccine from a different manufacturer, and onset of paralysis did not correlate with limb of injection in any patient. One of these patients, a 34-year-old man, became ill 8 days after the first injection and died 1 month later. In four other case families, a family member (other than the patient) had received Salk vaccine during the month before onset of poliomyelitis. A few cases of poliomyelitis in recently vaccinated persons and families were expected because public and private immunization activities increased greatly during the outbreak. During August, September, and October the health department held many mass, free, public vaccination clinics in neighborhood fire stations, offering first, second, and third injections to all persons under 50 years of age. These clinics were well publicized and were extended to evenings and Saturdays to facilitate vaccination of working men. In these clinics the health department administered 26,136 doses of Salk vaccine during August and 20,821 during September, largely to young adults. Nevertheless, the peak of the epidemic curve for adults occurred in October, and the outbreak continued until December.

Severity of Paralysis and Vaccination Status

In this outbreak of 113 cases of paralytic poliomyelitis, there was no significant correlation of severity of paralysis with number of doses of vaccine (table 7). Case fatality rates for unvaccinated patients (6.8 percent) and for triply vaccinated patients (5 percent) are very similar to the case fatality rate for all patients (7.1 percent). This finding, together with the fact that none of the 29 patients with two, three, or four shots recovered completely, suggests that the apparent lack of a modifying effect by vaccine is real, rather than due to limited numbers or difficulty in classifying residual paralytic disability as slight, moderate, or severe. The one triply vaccinated patient who died was a 36-year-old banknote salesman, father of five, who had completed an optimumly spaced series of three shots 18 months before onset of disease.

Racial and Religious Distributions

One hundred and five patients were white, seven were Negro (ages 1, 3, 3, 4, 5, 6, and 23 years), and one was Mexican. Based on the estimated population composition of the community (2.5 percent Negro), the Negro attack rate was approximately 2½ times that for the white population. In earlier years attack rates for Negroes were consistently lower than those for the white population (table 5).

Because surveys of vaccination status in schools, at beaches, and by telephone had revealed belief in Christian Science to be a frequent cause of nonvaccination, the religious preference of poliomyelitis patients is of particular interest. Three (2.6 percent) of the 113 poliomyelitis patients indicated membership in Christian Science churches, which have an

Table 7. Severity of paralysis in relation to number of Salk vaccine injections, Seattle-King County, Wash., 1959

Status 60 days after onset	Number of Salk vaccine injections								Total	
	0		1		2		3 or more			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Complete recovery	7	10	1	9	0	0	0	0	8	7
Slight residual disability	19	26	1	9	2	22	6	30	28	25
Moderate residual disability	20	27	5	45	5	56	8	40	38	34
Severe residual disability [1]	22	30	2	18	2	22	5	25	31	27
Dead	5	7	2	18	0	0	1	5	8	7
Total	73	100	11	99	9	100	20	100	113	100

[1] 26 of these 31 patients were still hospitalized 60 days after onset.

estimated membership of 16,000 persons (1.8 percent of the total population) most of whom reside in middle and upper socioeconomic areas. Two of the three patients were a husband and wife, neither vaccinated, who were hospitalized with bulbar disease. Type 1 poliovirus was isolated from both. Religious belief may have prevented vaccination of a few other patients who stated their religious preference hesitantly or without complete specificity and of a few patients who may not have sought medical treatment. Religion, however, was not the principal reason for nonvaccination among the 113 patients. Procrastination, apathy, ignorance, fear of needles, and doubts concerning safety of the vaccine were the main deterrents.

Paralysis and Tonsillectomy Distributions

Fifty-five patients had had tonsillectomy more than 6 months before onset of poliomyelitis, and 1 had had the operation within the 6-month period (table 8). The proportion of patients with a history of tonsillectomy increased greatly with age, from 1 of 30 preschool children to 45 (69 percent) of 65 adults. Similarly, the proportion of patients with bulbar paralysis increased with age, from 7 (23 percent) of 30 preschool children to 35 (54 percent) of 65 adults. In contrast with earlier reports (*2–9*), however, the distribution of tonsillectomy and bulbar paralysis in these 111 patients does not indicate that tonsillectomy more than 6 months before onset of poliomyelitis disposes to bulbar paralysis. Thirty patients who had had their tonsils removed had bulbar paralysis, whereas 29.5 such patients would be expected by chance association. Furthermore, a lesser proportion of adults with bulbar paralysis who died (4 of 7) than of adults with bulbar paralysis who survived (21 of 28) had a history of tonsillectomy.

The one patient who had had a tonsillectomy during the 6 months preceding onset of poliomyelitis was an unvaccinated 24-year-old hardware salesman. He had his tonsils removed on August 3, and became ill on August 22, with headache, sore throat, fever, moderate stiffness of his neck, and double vision on lateral gaze. Spinal fluid contained 105 white cells per cubic millimeter, 40 percent polynuclear, and type 1 poliovirus was isolated from his stool. He was hospitalized 4 days and recovered completely within 4 weeks.

Swimming and Poliomyelitis

Although 21 (46 percent) of the 46 poliomyelitis patients who became ill during June, July, and August had been swimming during the month preceding onset of their disease, they had used 15 different waters. Furthermore,

Table 8. Bulbar paralysis and tonsillectomy in paralytic poliomyelitis cases, Seattle-King County, Wash., 1959

Age group (years)	Paralytic cases	Paralytic cases with history of tonsillectomy		Bulbar cases		Bulbar cases with history of tonsillectomy	
		Number	Percent	Number	Percent	Observed	Expected
All children	46	10	22	16	35	3	5.03
0–4	30	1	3	7	23	0	.23
5–9	15	8	53	9	60	5	4.80
10–14	1	1	100	0	0	0	0
All adults	66	45	69	35	54	25	24.5
15–19	2	2	100	2	100	2	2.00
20–29 [1]	30	21	70	16	53	12	11.2
30–39	24	16	67	14	58	9	9.28
40 and over	9	6	66	3	33	2	2.00
Total [1]	111	55	50	51	46	30	29.5
Deaths [1]	7	4	57	7	100	4	4

[1] Two 24-year-old patients with paralytic poliomyelitis omitted, one because tonsillectomy was performed within 1 month of onset, and the other, a death, because tonsillectomy status was not ascertained.

for 15 (33 percent) of the 46 patients no history of swimming was elicited for any family member during 4 weeks preceding onset of disease. Swimming experience of patients and their families was significantly less than the community average, a finding perhaps associated with socioeconomic status. Among 89 families selected at random from the metropolitan telephone directory and queried during August, 70 percent of individuals and 86 percent of families (at least 1 member) had been swimming during the preceding month. Also, whereas July and early August were warm and favorable for swimming, the weather became less favorable about mid-August. Cool weather, in addition to the usual late summer decrease in swimming and public fear of contracting poliomyelitis, resulted in virtual cessation of swimming about mid-August, with no apparent effect on the mounting poliomyelitis occurrence.

Other Distributions

No unusual or suggestive association of cases with water, milk, food, physicians, dentists, insects, injections, or travel was observed.

Most of the patients (especially the early ones) used Seattle city water, which is obtained from an uninhabited watershed, chlorinated, and supplied to residents of Seattle by means of an adequate distribution system and with maintenance of good pressure.

Families of patients purchased milk and food from a large variety of sources, and no pattern was discerned which suggested unusual association with certain foods, such as specific fruits or vegetables, or with certain producers. It was, of course, impossible to exclude entirely the possibility of exposure to one or more foods derived from a common source, by means of necessarily limited food-source histories.

Seattle is ordinarily remarkably free of mosquitoes, flies, and other theoretical insect vectors. Such vectors were not generally unusually prevalent during 1959, and the experience of case families was not significantly different from that of other families in the community.

The data concerning contact of case families with ill persons during the month before onset of poliomyelitis do not permit a decision as to whether such contact had occurred with unusual frequency. Except for three multiple-case households, only two patients gave a history of recent contact with a known case of poliomyelitis. Onset of poliomyelitis in adults was frequently preceded by febrile illness in associated children, but in the absence of a control group it is not possible to state whether morbidity of children in case families differed from that of children in neighboring families.

Discussion

The data concerning the 113 paralytic poliomyelitis cases on which this analysis is based were obtained under fairly optimum circumstances: good communication and rapport exists between health department, physicians, hospitals, and the public. Therefore, reporting of detected poliomyelitis cases was undoubtedly nearly complete. Routine use of public health laboratory services facilitated specific diagnosis and permitted inclusion of some cases (including one death) which would likely have been missed in earlier years. Likewise, routine inspection of all death certificates led to an investigation which added another poliomyelitis death to the record, one which would also probably have been missed in earlier years. Even typical poliomyelitis deaths occurring in hospitals can evidently be missed, which suggests that findings of studies which include neither readily available laboratory facilities for poliovirus isolation, nor perusal of all death certificates and further investigation when indicated, may significantly understate mortality from poliomyelitis.

The unusually great proportion of adult cases recorded in this outbreak was probably the result of multiple factors. Undoubtedly, thorough vaccination of school children, considerable vaccination of preschool children, and unusually great prevalence of virulent type 1 poliovirus were important factors. In addition, an unusually great number of susceptible adults may have accumulated in this area during past years because of environmental factors of probable importance in the prevention of transmission of poliomyelitis (*9,10*), such as: (*a*) a generally excellent water supply, (*b*) the weather, which causes substantial modification of living and recreational habits during the generally cool summers (as compared with most

of the continent) and results in unusually low prevalence of flies and similar, possibly significant, mechanical conveyors of virus, (*c*) population distribution and topography, which facilitate such activities as fishing and boating and permit frequent excursions to relatively uncrowded beaches and mountain camps (*11*), and (*d*) better than average standards of personal and household hygiene. (Census data (*12*) indicate that Seattle adults over 25 years of age have completed a higher median number of years of education than adults in any other of the 50 largest cities in the United States.)

That the unusually large proportion of adult patients observed in this outbreak was not entirely due to subtraction of potential child patients by thorough vaccination of that age group is indicated by a previous finding (*13*) that in the 1952 outbreak, before vaccination, 43 percent of paralytic poliomyelitis patients in this community were adults. Furthermore, the sex reversal of adult patients and the large decrease in cases among pregnant women in the 1959 outbreak indicate that vaccination not only prevented cases in children but also prevented many cases in adults in this community. The concept that the large proportion of adult patients in the 1959 outbreak of poliomyelitis was considerably the culmination of natural environmental factors is supported by the consistent trend toward increased age at death from poliomyelitis in this community since 1900 (fig. 4).

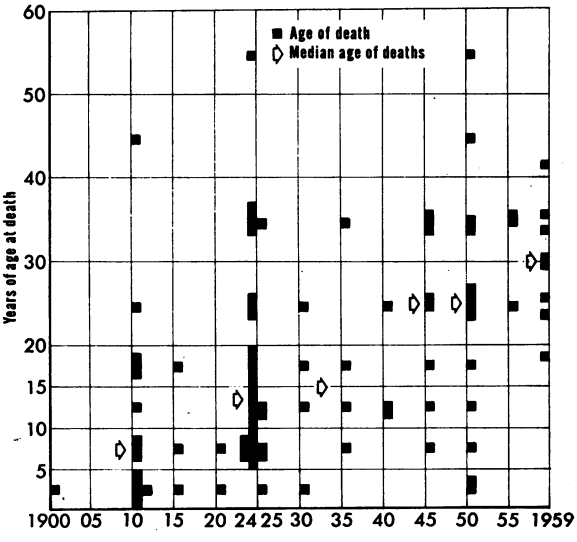
The concept that "the preventive effect of vaccine is more distinct as the severity of the disease increases" (*14*) received no support from the findings of this study (table 7). Paralytic disability was apparently equally severe in persons developing paralytic disease after complete, partial, or no vaccination, indicating that vaccination confers all-or-none protection. This conclusion, which was derived from analysis of this outbreak of 113 patients, is supported by findings of Dougherty and Faro (*15*) and H. W. Wylie, Jr., of the Public Health Service (personal communication).

Failure of bulbar paralysis to associate with greater than chance frequency with tonsillectomy performed more than 6 months previously demonstrates an instability of association of these two factors which indicates that reports of such an association in earlier studies (*3–8*) may not have been based on a cause and effect relationship. Rather, if bulbar paralysis and previous (not recent) tonsillectomy are sometimes associated with greater than chance frequency, the association is more likely a function of the age and the socioimmunological status of poliomyelitis patients. This interpretation of the findings of this study is supported by the usual greater occurrence of bulbar paralysis in adults than in children in "virgin soil epidemics" in populations with tonsils intact (*16*).

Very few tonsillectomies were performed in this community during the poliomyelitis season. Hence the occurrence of bulbar poliomyelitis in one person shortly after tonsillectomy enforces the general belief, based on considerable experience, that tonsillectomy does dispose to bulbar paralysis during the first subsequent month.

The occurrence of this poliomyelitis outbreak in a community which had had unusually good access to vaccination (*17*) has caused considerable concern and deserves explanation. Study and reflection lead to the following hypothesis:

Figure 4. Age distribution of poliomyelitis deaths, every fifth year 1900–55, and epidemic years, 1924 and 1959, Seattle-King County, Wash.



NOTE: Age of poliomyelitis deaths ascertained by inspection of all death certificates recorded in the indicated years.

Despite (and perhaps because of) extensive Salk vaccination in this community, a large proportion of preschool children in the lowest socioeconomic areas remained susceptible to type 1 poliovirus. During 1959 virulent type 1 poliovirus was introduced into these pockets of susceptible preschool children, where it was propagated and spread by contact, perhaps especially by the fecal-oral route, by the young children to their playmates and parents.

Accumulation of an unusually susceptible preschool population in some areas was apparently due to (*a*) unusually low prevalence of poliovirus in this community during the previous 3 years and (*b*) failure adequately to replace declining natural immunization with artificial immunization in preschool children in public housing projects and similar low socioeconomic areas.

The effect of extensive immunization with Salk vaccine on the propagation and distribution of poliovirus is a controversial topic, with the consensus being that such immunization does not alter its distribution (*18–21*). This point of view, which has been especially espoused by proponents of live virus vaccine, is apparently based largely on studies of poliovirus distribution, according to vaccination and antibody status, in members of certain Louisiana households (*18*, *20*, *21*) and on poliovirus distribution in household contacts of paralytic poliomyelitis cases (*19*). A review of the data presented in these studies causes diminished confidence in the accuracy of the conclusions.

In 1956, for example, it was stated that "two doses of Salk vaccine did not materially influence the frequency of alimentary infection or the amount of virus excreted in the feces" (*18*). This conclusion was based mainly on the finding that in the study population household episodes of poliovirus infection occurred with approximately the same frequency during 1956, after two doses of Salk vaccine, as in 1955, before vaccination. It was noted, however, that a reduction did occur in the "estimated true mean of virus excretion (37.7 days after vaccination and 51 days before), of uncertain significance." The following year, after the study population had received a third dose of vaccine, a moderate diminution in the duration of poliovirus excretion in feces was again observed, but it was concluded that "widespread use of Salk vaccine should not by any reasonable mechanism influence poliovirus dissemination" (*20*). This conclusion was reiterated despite a sharp decline in household episodes of poliovirus infection in 1957, which was discounted as a "natural variation in dissemination of virus, due to causes as yet unknown." However, it was failure to observe such a decline in 1956 which was the cornerstone of the conclusion that immunization with Salk vaccine exercised no influence on the distribution of poliovirus in the community. Hence, the excellent data derived from these studies are not as decisive as the conclusions made concerning the lack of effect of immunization with Salk vaccine on poliovirus distribution.

Similarly, from a study of poliovirus excretion by household contacts of poliomyelitis patients the statement was made that "the quantity of virus in the feces of vaccinated children is not detectably different from that in the specimens of those not vaccinated," despite presentation of data which show that the median negative log of poliovirus titer in fecal specimens of those vaccinated was 2.0 (45 determinations), whereas in feces of those not vaccinated it was 2.78 (95 determinations) (*19*).

Other investigators have found poliovirus less frequently and in less quantity in the pharynx or feces, or both, in vaccinated experimental animals and household contacts of poliomyelitis cases than in those not vaccinated (*22–27*).

Although conclusions of investigators vary greatly, their data are in general accord with the concept that immunization with Salk vaccine, especially three or more injections, causes moderate reduction in the frequency, duration, and titer of alimentary poliovirus infection of humans and experimental animals exposed to infection. This interpretation of the data is supported by the changed epidemiological pattern of poliomyelitis occurrence observed since vaccination was begun. The rapid decline in poliomyelitis incidence in Seattle-King County, as well as nationally (*28*), during 1956–57 could have been mere coincidence, or due entirely to direct protection by the vaccine. But the abrupt absolute as well as relative increase in

attack rates among lower socioeconomic groups, especially residents of public housing projects and preschool Negroes, which has been observed during the last 3 years in Seattle-King County (table 5) and elsewhere (*27*, *28*) indicates a fundamental disturbance of poliovirus ecology, probably due to vaccination. If so, eradication of poliovirus from large populations by more nearly universal immunization with Salk vaccine may be possible. Such eradication of poliovirus from a community, however, would be temporary and hazardous if pockets of highly susceptible preschool children were permitted to develop. Permanent success in the prevention of epidemiogenic pockets of susceptible preschool children will probably depend on perennial extension of community vaccination programs. Improvements in existing vaccination programs should be designed particularly to achieve early vaccination of preschool children in the lowest socioeconomic groups, who are currently the prime propagators of poliovirus (and many other infectious agents). Adequate immunization of this high-priority group, without resorting to legal compulsion, can probably be achieved by persuasion, by making vaccination maximally available, and by a cooperative arrangement between the health department and public housing authorities which would facilitate vaccination of virtually all families moving into public housing projects.

Summary

Investigation of 113 cases of paralytic poliomyelitis which occurred in Seattle-King County in 1959 revealed the following epidemiological patterns:

The outbreak was largely, perhaps entirely, caused by type 1 poliovirus, which was isolated from 65 (82 percent) of the 79 patients from whom stool specimens were examined.

The outbreak began in June, reached peaks in August, September, and October, and ended in December. Median week of onset in children preceded median week in adults by about 3 weeks.

A predilection for cases to occur in the lower socioeconomic families, especially among residents of public housing projects in southwest Seattle-King County, was discerned. Four cases occurred among 1,200 families in one housing project during August and September despite a door-to-door vaccination program during June.

The Negro attack rate was approximately 2½ times that for the white population.

Religious belief was the cause of nonvaccination for at least three patients.

Swimming was not a significant factor in the epidemiogenesis of this outbreak.

Sixty-seven (59 percent) of the 113 patients were adults. Ages ranged from 9 months to 57 years, with a median of 22.5 years. Patients who died ranged in age from 19 to 42 years, with a median of 30.5 years. Seventy-two (64 percent) of the 113 patients and five (62 percent) of the eight who died were male. Only two cases in pregnant women were recorded.

Only two of the 67 adult patients had not had regular household contact with children during the month prior to onset.

Seventy-three (65 percent) of the 113 cases had received no vaccination before onset; 11 (9.7 percent) had received one shot; 9 (8 percent), two shots; 19 (16 percent), three shots; and 1, four shots.

Severity of paralytic disability showed no significant correlation with number of vaccine injections, indicating that the vaccine provides all-or-none protection.

Distribution of tonsillectomy and bulbar paralysis did not indicate that previous (not recent) tonsillectomy disposes to bulbar paralysis.

This outbreak was probably due especially to accumulation of an unusually susceptible preschool population in public housing projects and similar low socioeconomic groups. This accumulation indicates unusual lack of natural immunization which, with the very low incidence of poliomyelitis during recent years and the changes in racial, socioeconomic, and geographic distribution of cases, suggests that extensive use of Salk vaccine did temporarily limit propagation of poliovirus in this community.

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