Epidemiology of Poliomyelitis in Israel, 1952-59 *

With Evaluation of Salk Vaccination During a Three-Year Period

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The epidemic of poliomyelitis which occurred in Israel in 1958 among a population a large proportion of which had received inactivated Salk-type vaccine aroused great interest. This was the first time a vaccinated infant population had been exposed to a severe epidemic and thus afforded the first opportunity to determine whether or not vaccination afforded a high degree of protection in this age-group. The authors report on the observations made.

While the vaccine conferred some protection, this was not of so high a degree as had been expected from experience elsewhere in older children. This partial failure may be explained in part by the use in the earlier vaccination campaigns of vaccines of lower potency than is now current and perhaps by the fact that many vaccinations were performed intradermally.

No very exact measure of the protection conferred can be given. For some groups the figures are too small for statistical validity; for others, it is not possible to distinguish between the effect of vaccine and that of age, the latter possibly being the more important factor.

The transition of poliomyelitis in Israel from a sporadic to an epidemic disease began in the autumn of 1949 followed by a severe epidemic in 1950 of 1621 cases, representing an attack rate of 12.8 per 10 000. The 1950 outbreak was followed in 1951 by a somewhat milder epidemic with a total of 918 cases. A detailed description and analysis of the 1950-51 epidemics was given by Yekutieli et al. (1955), and the clinical aspects were described by Falk (1951) and Marberg (1952).

From 1950 until 1957 the attack rate of poliomyelitis in Israel remained high, with an annual incidence never falling below 2.3 per 10 000. Poliomyelitis rates for the period 1940-59 are shown graphically in Fig. 1. Throughout these years and until the present, the disease has retained its infantile character, 85%-90% of all cases occurring under 5 years of age.

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FIG. 1
 POLIOMYELITIS ATTACK RATES PER 10 000, ISRAEL,
 1940-59 (JEWS ONLY)

In 1957 there was an acute drop in incidence contemporaneous with the mass immunization with Salk vaccine of the most susceptible age-groups. In spite of the continued immunization programme, however, there was a sharp rise in incidence of the disease in 1958, followed again by a decline in 1959.

The purpose of this report is to present the epidemiological background of poliomyelitis in Israel and to analyse the effectiveness of immunization with Salk vaccine during the period 1957-59.

GENERAL OBSERVATIONS

The standard of reporting of poliomyelitis cases is extremely high in both Jewish and non-Jewish population groups. The overwhelming majority of the paralytic cases (and often, of the non-paralytic cases) are referred to one of three hospitals where they are seen by clinicians with considerable experience in the disease. Thus, the number of cases as well as the diagnosis may be accepted with confidence. From 1957 onwards each case discharged from hospital has been reviewed as to diagnosis and rehabilitation therapy by a medical board.

In 1950-51, 25%-28% of notifications were of non-paralytic cases; this dropped to 10%-12% in subsequent years, and in 1957-59 only proved paralytic cases have been included in the statistics.

Since 1952, the seasonal pattern has been fairly constant, with an increase in cases in the late spring and a peak in June or July, paralleling the rise in mean temperature (Fig. 2).

In 1950, the epidemic spread centrifugally from the central regions of the country but this pattern was not repeated in subsequent years, the affected areas varying from year to year. In addition, the severity of the outbreak in any one district is unpredictable. A description of the position in the southern region for the years 1950-57 has been given by Nathan (1959) and for Jerusalem in 1953 by Adler et al. (1955).

The possible role of mass immigration and the living conditions of the immigrants in the epidemics of 1950-51 have been discussed by Yekutieli et al. (1955). Immigration slackened off between 1952 and 1956, when it again showed an upward spurt. Even so, there was a steady stream of new arrivals between 1952 and 1955 of about 20 000 a year, mainly from Asian and North African countries. The rise to 70 000 in 1957 and the 26 000 in 1958 included, once more, an increase in immigrants from Central and Eastern Europe. By 1957, the immigrant camps,

FIG. 2
PROPORTIONAL MONTHLY POLIOMYELITIS RATES AND
MAXIMUM AND MINIMUM TEMPERATURES, ISRAEL,
1953-57

with their crowded unsanitary conditions, contained only 20 000 families and the general standard of housing and nutrition had improved.

The non-Jewish population of Israel deserves special mention. Their numbers rose from 183 000 to 220 000 during the period 1953-58. They are mostly distributed in compact communities in villages and small towns in the north and central part of the country. About 14 000 Bedouin inhabit the south of Israel.

INCIDENCE AND AGE DISTRIBUTION OF CASE, 1952-56

Numbers of cases and attack rates from 1950 to 1956 are given in Table 1. Although there was a decrease in the number of cases following the severe 1950-51 outbreaks, the incidence during the five-year period 1952-56 was still very high, with an average of 650 cases per year.

Attack rates among the non-Jewish (mainly Arab) population showed considerable variations from year to year. In 1950, the Arab rate was 1.0 per 10 000, less than one-tenth of the total rate. This disproportion between the Jewish and non-Jewish rates diminished until 1955, when the Arab rate was actually higher. The same situation obtained in 1957.

TABLE 1
NUMBERS OF POLIOMYELITIS CASES NOTIFIED AND
ATTACK RATES IN ISRAEL, 1950-56

Year	No. of cases	Attack rate per 10 000	
		Jews	Non-Jews
1950	1 621	14.5	1.0
1951	918	6.9	0.2
1952	874	5.8	2.3
1953	636	4.2	0.9
1954	785	5.0	1.9
1955	468	2.3	3.7
1956	533	3.0	0.8

The disease has maintained its identity as an infantile paralysis with variations in the proportions of the different age-groups from year to year, 85%-90% of all cases being under 5 with nearly 80% under 3 years of age. Indeed, Israel is the prototype for Payne's group 1 epidemiological pattern (Payne, 1958). The age distribution of the cases, with age-specific rates and percentages by age for the years 1954, 1955, 1956 and 1958, is given in Table 2. For

comparison, rates and percentages for 1951 are added.

PREVALENCE OF POLIOVIRUS STRAINS

Data on the prevalence of the various poliovirus immunological types prior to 1957 are rather limited. Three isolates from paralytic cases in 1950 were typed in the laboratories of the Yale Poliomyelitis Unit and turned out to be type 1 poliovirus (Marberg, 1952). During later years, in addition to the predominant type 1, type 2 and 3 strains were also shown to occur (Bernkopf, 1954; Bernkopf & Levine, 1955). A limited study carried out during the 1955 poliomyelitis outbreak revealed that of 52 poliovirus strains isolated, 38 were type 1 poliovirus, which constitutes 75% (N. Goldblum—unpublished data). Thus, all evidence points to poliovirus type 1 as the main etiological agent of the poliomyelitis outbreaks during the period 1950-56.

From 1957 until the present (February 1960) detailed isolation studies and typing of all isolates from paralytic and non-paralytic cases have been carried out, mainly in the Virus Laboratory of the Ministry of Health. In 1957, the first year of Salk vaccination, of 36 poliovirus strains isolated from paralytic cases, only 4 were type 1, while 19 were type 2 and 13 were type 3 (see below). During the

TABLE 2
AGE-SPECIFIC RATES (PER 10 000 TOTAL POPULATION) AND PERCENTAGE AGE DISTRIBUTION
OF POLIOMYELITIS IN ISRAEL, 1951, 1954-56 AND 1958

Age	1951		1954		1955		1956		1958	
	Rate ^a	%	Rate ^a	%	Rate ^a	%	Rate ^a	%	Rate ^a	%
<1	58.8	26.3	55.8	33.5	27.6	27.3	30.0	26.0	37.4	31.4
1	80.1	32.8	41.3	25.5	29.5	32.2	34.0	29.1	39.0	34.1
2	39.9	14.7	29.8	18.6	17.0	18.5	20.4	18.0	18.2	14.8
3	17.2	6.5	14.6	8.9	6.1	6.7	8.7	8.0	8.1	7.2
4	15.5	6.0	8.2	4.5	4.7	5.0	4.3	4.9	4.6	4.0
5-9	7.6	8.6	2.6	6.2	1.7	7.5	2.4	9.4	1.9	7.2
10-14	1.5	1.7	0.4	0.4	0.4	1.3	0.7	1.8	0.2	0.8
15+	0.6	3.4	0.2	2.4	0.2	1.5	0.3	2.8	0.03	0.5
Total rate	6.9		5.0		2.3		3.0		2.9	
Total cases notified	918	100.0	785	100.0	468	100.0	533	100.0	573	100.0

^a Differences between attack rates at different ages are highly significant ($P < 0.01$).

1958 epidemic, type 1 poliovirus became the dominant strain, accounting for 97% of all isolations. In 1959, type 1 isolations were again scarce. These changes in the prevalence of the poliovirus types and especially the "disappearance" of type 1 in 1957 and its reappearance in 1958 are of fundamental importance both for understanding the epidemiology of poliomyelitis in Israel and for the interpretation of the effectiveness of immunization with Salk vaccine. These will be discussed later in this report.

STATE OF IMMUNITY TO POLIOMYELITIS

One of the main features of the epidemiology of poliomyelitis during the period reviewed is the predominantly infantile character of the paralytic disease and the scarcity of cases among older children and adults. This indicates a high susceptibility of infants and young children and "solid immunity" in the higher ages. Such a situation closely resembles immunity patterns prevailing in other subtropical areas (Paul et al., 1952; Paul & Horstmann, 1955; Payzin & Murray, 1957). Indeed, poliomyelitis antibody studies carried out in the past in Israel (Bernkopf & Levine, 1955) have confirmed this relationship between age and immunity. A survey of the status of maternal antibody in infants up to 6 months of age, carried out by Spigland &

Goldblum (1960) showed the presence of poliomyelitis antibody for all three poliovirus types in a very high percentage of infants at birth. From birth until 6 months of age there was a gradual fall in the percentage of infants with antibody, and at the age of 5-6 months almost 90% were without antibody to all three poliovirus types. Thus, at the age of 6 months, the vast majority of infants are without antibody cover and therefore highly susceptible to infection and paralysis (Yekutieli et al., 1955). This situation is illustrated in Fig. 5 (see below). Immunity to all three types of poliovirus, and especially to type 1, is gained at an accelerated pace from 6 months of age onwards. This is shown in Table 3, which presents the results of an antibody survey carried out in 1956, prior to the introduction of Salk vaccination. The survey included 481 infants and children, aged 3-48 months, from various areas of the country. The numbers and percentages of susceptibles become less and less with advancing age, and at the age of 4 years 86%-95% of the children have antibody to the three poliovirus serotypes.

These antibody patterns together with the high incidence of the disease limited to infants and young children were the basis for the immunization programme started in the winter of 1957 and which covered mainly infants and children 6 months to 4 years of age.

TABLE 3
PRE-VACCINATION ANTIBODY LEVELS TO THE THREE POLIOVIRUS TYPES IN ISRAEL AT AGE 3-48 MONTHS, AUTUMN 1956

Age-group (months)	No. Tested	Antibody to						No antibody		Antibody to all 3 types	
		Type 1		Type 2		Type 3					
		No.	%	No.	%	No.	%	No.	%	No.	%
3-6	85	15	18	16	19	12	14	53	62	3	4
7-12	90	33	37	9	10	23	26	42	47	3	3
13-18	84	56	67	16	19	29	35	18	21	9	11
19-24	68	53	78	28	41	38	56	6	9	18	26
25-20	65	56	86	44	68	52	80	2	3	34	52
31-36	52	46	88	41	79	47	90	0	—	33	63
37-48	37	35	95	33	89	32	86	1	3	30	81

THE IMMUNIZATION PROGRAMME

The 1957 campaign

In view of the favourable results with Salk vaccine (Poliomyelitis Vaccine Evaluation Center, 1957) as well as of the local morbidity figures for the years 1950-56, the decision was taken by the Ministry of Health to commence vaccination against poliomyelitis at the beginning of 1957. Local production of vaccine started in April 1956, and by the end of the year this, together with a quantity of Salk vaccine from the USA, gave a sufficient amount in stock.

The aim of the first vaccination campaign, which started in January 1957, was to immunize the most susceptible age-groups (6 months to 3 years) by May 1957. These were the children of "campaign age". Two basic injections, one month apart, were given as primary immunization. The majority of the eligible children received these injections between January and April. When additional amounts of vaccine became available, children 3 years to 3 years and 8 months old, as well as children and adults up to the age of thirty who had recently immigrated from Western Europe and America, were drawn into the campaign. The latter group was chosen because the experience of previous years had shown their greater susceptibility to poliomyelitis (Yekutieli et al., 1955). To these were added infants, 4-5 months old, who received their basic inoculations during May and June. No further immunizations were given that year.

At the beginning of the campaign a method of immunization similar to that recommended by Danish workers (von Magnus et al., 1955; Tulinius & Henningsen, 1955) was used, consisting of intradermal injections of 0.3 ml, given in two divided doses, at the same session. This technique was adopted mainly in order to save vaccine. Because of technical and administrative difficulties, the intradermal method was abandoned in March, and from then on subcutaneous injections of 0.5 ml each were given.

All vaccine used was supplied free by the Government. The campaign was organized within the framework of the public health services (Ministry of Health, district health offices, municipalities, sick funds and voluntary organizations). Special immunization teams were organized consisting of one inoculator (doctor or nurse), two medical aides (nurses) and two registrar-clerks. The teams operated partly in mobile units, visiting every settlement in the country and partly in stationary

clinics in towns and larger villages. An intensive propaganda effort carried out in numerous lectures and meetings, as well as announcements in the press and the radio, preceded the campaign. The vaccination was carried out on a voluntary basis, and special permission was not demanded from parents bringing their children for vaccination.

The total number of candidates of "campaign age", 6 months to 3 years, was about 126 000. Some 113 000 children of this group, representing 89%, were given the first inoculation, and of these 97.5% received the two basic injections. While 95% of the eligible Jewish population responded, only 65% of the non-Jewish (mainly Arab) population, came for vaccination. The response of the additional age-group of children (3 years to 3 years 8 months) called for vaccination was less satisfactory, with only about 20 000 (i.e., 50%-60% of those eligible) being included. The number of "western immigrants" receiving the basic immunization was about 4000.

Immunization in 1958

In January and February 1958 booster (third) injections of 0.5 ml of locally produced Salk vaccine were administered subcutaneously to the recipients of the basic immunization. A total of over 95% were reached. In March and April 1958 two basic inoculations were given to all infants born in 1957. 47 000 infants out of 52 000 eligibles (i.e., about 90%) received the first injection, while 85% of them received both basic injections. When, by May 1958, it became clear that the poliomyelitis incidence was rising steeply, and as there were doubts regarding the dosage and efficacy of the vaccine used previously, it was decided to give a third injection (early booster) to the infants born in 1957 who had received basic vaccinations in March and April 1958. This programme was carried out during June and July 1958, mainly with imported vaccine. It was also decided to raise the individual dose administered to 1 ml subcutaneously. Almost all the eligible infants were vaccinated in this campaign.

In June and July 1958 all infants between 4 and 6 months of age received their basic immunization of two, 1-ml, injections of locally produced Salk vaccine, subcutaneously, four weeks apart. In the following months the vaccination programme was changed from a "campaign" pattern to a decentralized activity on a local level. Each month all infants attaining the age of 4 months were called up by the local Government District Health Office, usually by direct personal invitation to the parents,

for basic immunization with locally produced Salk vaccine. All the recipients were asked to report again for the booster injection four to seven months later. While Salk vaccination was thus integrated into the routine general vaccination schedule, some slackening of the response of the public made itself felt. Owing to this administrative change full statistical data are not available, but it is estimated that between 80% and 90% of infants received their inoculations according to the schedule outlined above.

Immunization in 1959

In accordance with recent recommendations (Salk, 1958), it was decided to add a fourth injection for children born in 1957, who were the principal victims of the 1958 poliomyelitis epidemic. A subcutaneous inoculation of 1 ml of locally produced Salk vaccine was given to the vast majority of this group of children during March and April 1959.

During all months of the year, routine inoculations with basic and third booster injections of Salk vaccine were continued, according to the schedule given above. A complete analysis is not yet available, but attendance is estimated at 75%-80%.

General remarks

In summary, since the beginning of 1957 a vaccination programme with Salk vaccine has been carried out in Israel, encompassing the vast majority of persons in the susceptible age-groups. According to the figures available, more than 80% of the Jewish population and about 60% of the non-Jewish (mainly Arab) population, have been included.

It should be pointed out here, that during 1957 and 1958 there was a big public demand for vaccine for older children as well. An unknown amount of Salk vaccine was obtained privately for immunizing part of the child population, the injections being given by private physicians. In the absence of data

TABLE 4
ANTIGENICITY OF VACCINE LOTS USED IN ISRAEL DURING 1957-59

Period of immunization	Age-groups immunized	Type of immunization	Vaccine lot	Guinea-pig extinction titre to type		
				1	2	3
Winter and spring 1957	6-36 months (campaign age)	Primary	FLA	0.6	1.7	1.5
			FLB	0.9	1.4	1.8
			FLD	1.3	1.7	1.5
			American I	1.1	≥ 2.0	1.5
Winter and spring 1958	1. 6-36 months	Booster	FLK	1.2	1.5	1.3
	2. Born during 1957	Primary	FLM	1.4	1.7	0.8
			FLN			
May 1958 to end of 1959	1. 4-5 months	Primary and boosters	FLO	≥ 2.4	3.2	2.5
			FLP	3.1	≥ 3.0	≥ 3.0
			American II	≥ 2.2	N D	≥ 2.5
			TRP 9	2.5	3.3	1.6
	2. Born during 1957	Booster (4th injection)	TRP 11	1.8	≥ 3.0	≥ 3.0
			TRP 12	≥ 2.5	1.8	3.2
			TRP 14	2.5	2.0	2.3
			Salk reference vaccine J	≥ 1.9	≥ 2.5	≥ 2.4
			NIH reference vaccine	2.3	2.5	≥ 2.5

ND = Not done.

as to numbers, vaccine potency and mode of inoculation, it is impossible to evaluate the impact of such "clandestine" immunization.

With Salk vaccine available in regular supply from local production, a certain liberalization of the vaccination programme was decided upon during 1959 and small amounts of vaccine were made available for sale to the public.

VACCINES USED IN THE IMMUNIZATION PROGRAMMES

The poliomyelitis vaccines used in the immunization programmes of 1957-59 were of the formalinized Salk type. In the winter and spring of 1957, both American and locally produced vaccines, mainly the former, were employed. From 1958 onwards, locally produced vaccines were used almost exclusively with the exception of one lot of American vaccine which was given in the summer of 1958 as part of the third inoculation to infants born in 1957.

The locally produced vaccines were prepared according to methods described earlier (Goldblum et al., 1957, 1959). The volumes of the various vaccine lots released for use varied between 40 and 70 litres. The antigenicity of the various lots as measured by the guinea-pig antigenic extinction titre is shown in Table 4, from which it will be seen that the potency of the vaccine had undergone marked changes during the three-year period of immunization. The vaccines, both American and local, used for immunization in 1957 and until May 1958 were of relatively low potency, especially for type 1 antigen. Those used from May 1958 onwards were much superior and had guinea-pig antigenic extinction titres approximately 10-30 times higher than those used previously. This higher potency of the later lots of local vaccine was due to the omission of the second Seitz filtration during the inactivation period (Goldblum et al., 1959) and also to an increased proportion of type 1 antigen in the trivalent vaccine.

These variations in vaccine potency could also be seen by testing their effectiveness in non-immune (triply negative) infants. Table 5 shows the antibody response of triply negative infants, 4-6 months of age, to primary immunization with the various vaccine lots used. There is a correlation between the guinea-pig antigenic extinction titres (see Table 4) and the percentage of serological conversion in triply negative infants. Vaccines employed for immunization in 1957 gave significantly lower conversion rates than those used in 1958 and 1959.

Further evidence of the poor performance of the early vaccine lots and the high efficiency of the

TABLE 5
CONVERSION RATES OF 4-6 MONTHS-OLD INFANTS
WITHOUT ANTIBODY (TRIPLE-NEGATIVE)
AFTER PRIMARY VACCINATION WITH DIFFERENT
VACCINE LOTS

Vaccine lot	Poliovirus type	No. infants tested	Percentage conversions (to 1:4 or more)
FLA and FLB	1	80	20
	2		85
	3		25
FLD and American I	1	100	28
	2		95
	3		32
FLO	1	60	71
	2		98
	3		53
TRP 9	1	40	95
	2		100
	3		12.5
TRP 12	1	35	58
	2		48
	3		66

vaccines used from May 1958 onwards is brought out in Table 6, in which are presented results of antibody tests on infants 12-18 months old, carried out in the spring of 1958 and in the summer of 1959. The bloods for these tests were taken at random from infants who had presumably undergone a complete

TABLE 6
RANDOM ANTIBODY TESTS IN 12-18-MONTHS-OLD
INFANTS IN 1958 AND 1959

Year born	Date of test	No. tested	Percentage with antibody at 1:8 dil. to poliovirus type		
			1	2	3
1957	Spring 1958	80	42	68	64
1958	Summer 1959	72	74	80	68

TABLE 7
POLIOMYELITIS IN ISRAEL IN 1957 BY MONTH
OF ONSET AND VIRUS TYPE

Month	No. of cases	Poliovirus isolated			
		Type 1	Type 2	Type 3	Total
Jan.	7	Not done			
Feb.	0	—	—	—	—
March	1	1	—	—	1
April	0	—	—	—	—
May	5	2	3	—	5
June	8	1	3	—	4
July	8	—	5	1	6
Aug.	7	—	4	3	7
Sept.	4	—	1	—	1
Oct.	11	—	1	7	8
Nov.	4	—	2	1	3
Dec.	2	—	—	1	1
Total	57	4	19	13	36

FIG. 3
TOTAL POLIOMYELITIS CASES IN ISRAEL, 1958,
BY MONTH OF ONSET

series of immunization, that is, two primary inoculations at the age of 4-6 months and a booster inoculation six months later. Less than half of the infants tested in the spring of 1958 had type 1 antibodies while in the summer of 1959 over 70% were positive for type 1. There were no marked differences in the antibody titres for types 2 and 3.

INCIDENCE OF POLIOMYELITIS IN 1957

A total of 57 cases was confirmed from a larger number of notifications. This represents a total rate of 0.3 per 10 000, or a tenth of the rates in 1956 and 1958. The fall in incidence was most marked after the first year of life. For that year the age-specific

TABLE 8
VIRUS ISOLATIONS ^a BY MONTH, 1958

Virus type	Total ^b	Jan.-April	May	June	July	August	Sept.-Dec.
Polio 1	406	10	57	103	135	80	21
Polio 2	9	7	1	1	0	0	0
Polio 2	14	8	0	5	1	0	0
Not poliovirus ^c	17	0	0	4	8	1	5
Negative	112	6	6	34	34	18	14
Not typed	75	5	5	16	16	18	15
Total ^b	633	36	69	163	193	117	55

^a Performed by the Virus Laboratory of the Ministry of Health, and, for the Jerusalem area, by the Virus Laboratory of the Hadassah Medical School, Hebrew University (Professor H. Bernkopf).

^b Including non-paralytic and non-poliomyelitis cases.

^c Mainly ECHO and Coxsackie viruses.

rate was 6.8 per 10 000 compared with 30 in 1956 and 37.4 in 1958. Some 58% of all cases were under 1 year of age and 92% under 5 years. The monthly incidence curve was undulating, perhaps because of the small numbers (Table 7). As noted above, over half the strains of poliovirus isolated were of type 2 and a third of type 3.

THE EPIDEMIC OF 1958

The winter of 1957-58 was unusually mild and spring came early. Cases of poliomyelitis began to appear in January and February (Fig. 3) and the fact of the epidemic was obvious by May. A total of 573 paralytic cases was finally reported, giving a rate of 3.0 per 10 000 in the Jewish community and 2.0 per 10 000 in non-Jews. The epidemic wave is shown in Fig. 3.

Geographical incidence and virus types

During the first four months of the year nearly half of the cases were in the northern region, many of them among the minorities. Out of 25 polioviruses isolated at that time 15 were type 2 or 3 (Table 8), mainly from cases in non-Jews (Table 9). By the beginning of May, type 1 had become the predominant strain and the central region the most involved. June and July established the final picture, Jerusalem and the southern region (including Ashkelon) being most heavily attacked, with scattered cases all over the country and Tel-Aviv and Haifa relatively unaffected (Fig. 4). Table 10 shows the rates by month and district with the relevant population figures.

The epidemic did not single out particular communities or types of settlement as it did in 1950 (Yekutieli et al., 1955).

FIG. 4
POLIOMYELITIS ATTACK RATES PER 10 000 TOTAL POPULATION IN ISRAEL, 1958, BY REGION

TABLE 9
ASSOCIATION BETWEEN ETHNIC GROUP AND TYPE OF VIRUS
(FROM PARALYTIC CASES ONLY), 1958

	Poliovirus type 1	Viruses other than poliovirus type 1 ^a	Negative	Total examined	Not examined	Total cases
Jews	367	23	88	478	51	529
Non-Jews	18	10	4	32	12	44
Total	385	33	92	510	63	573

^a The association between non-Jews and viruses other than poliovirus type 1 (mainly poliovirus types 2 and 3) is highly significant ($\chi^2 = 34.45$; $P < 0.001$).

TABLE 10
MONTHLY RATES OF PARALYTIC POLIOMYELITIS CASES (PER 10 000 TOTAL POPULATION) BY DISTRICT, 1958

Month	Tel-Aviv	Jerusalem	Haifa	North	Centre	South ^a	Total
Jan.-April	0.03	0.17	0.08	0.38	0.13	0.37	0.16
May	0.22	0.40	0.20	0.30	0.51	0.44	0.32
June	0.58	0.80	0.20	0.63	0.74	2.72	0.75
July	0.62	2.12	0.39	0.81	0.77	2.35	0.91
August	0.30	1.72	0.43	0.43	0.31	1.32	0.54
Sept.-Dec.	0.16	0.11	0.20	0.58	0.08	0.29	0.24
Total rates	1.92	5.33	1.49	3.14	2.53	7.50	2.90
Population x10 ³	624.1	174.3	255.5	394.5	391.3	136.1	1 976

^a Ashkelon and the Negev.

There was a highly significant association between district of residence and age, both for the total population and for Jews separately. Paralytic cases in the southern, central and northern regions tended to be younger, while those in the Tel-Aviv area tended to be older. Jerusalem occupied an intermediate position (Table 11). This may be partially explained by the concentration of families of European origin. In Tel-Aviv 54% of cases were from European families, as compared to the national figure of 25.5% (see below).

Incidence by age

The pattern of age-group susceptibility did not differ from that of previous years for both Jews and

Arabs (Table 2 and Fig. 5). Especially susceptible, as formerly, was the 6-24-months-old child. The rapid falling off in the attack rate after 2 years of age meant that in many cases the protective value of age was greater than the protective value of vaccination, a fact which complicates the analysis of vaccine efficiency (see below). Fig. 6 illustrates the rise in incidence rates paralleling the fall in antibodies during the first 6 months of life.

Ethnic groups

Non-Jews. Of the total of 573 paralytic cases 44 were among the minorities, 41 in Arabs, 2 in Druze and one in a non-Arab Christian. The rate of 2.0 per 10 000 was lower than that in Jews and was only

TABLE 11
AGE OF PARALYTIC POLIOMYELITIS CASES AMONG TOTAL ISRAEL POPULATION BY DISTRICT, ^a 1958

Age (years)	Tel-Aviv	Jerusalem	Haifa	North	Centre	South	Total
<1	21	30	8	42	34	39	174
1	32	31	13	47	36	40	199
2	14	12	6	21	16	16	85
3+	51	20	10	14	13	9	117
Total	118	93	37	124	99	104	575 ^b

^a The association between age and district is highly significant ($\chi^2 = 60.66$; $P < 0.001$; 15 degrees of freedom). For the 531 Jewish cases taken separately, $\chi^2 = 60.69$; $P < 0.001$; 15 degrees of freedom.

^b Two Jewish cases were subsequently rejected as non-paralytic.

FIG. 5

AGE-SPECIFIC POLIOMYELITIS ATTACK RATES
PER 10 000 IN ISRAEL, 1958 (JEWS ONLY)

FIG. 6

AGE-SPECIFIC POLIOMYELITIS ATTACK RATES
PER 10 000 IN ISRAEL, 1958, IN RELATION TO LOSS
OF MATERNAL ANTIBODIES (JEWS ONLY)

three times higher than the 1957 rate for the minorities. For the total population, on the other hand, the 1958 rate was ten times that of 1957. The age distribution of cases was similar to that in the Jewish population but there was a preponderance of cases due to virus types 2 and 3, as shown in Table 9. The case fatality was about 7%.

Jews of various origins. Jews in Israel may be divided into four groups: those born in Israel (and former Palestine) and immigrants from Asia, from North African countries and from Europe and America. This last group enjoys, on the whole, a somewhat higher standard of living.

The increased susceptibility to poliomyelitis of new Yemenite immigrants in 1950 was discussed by Yekutieli et al. (1955). As already stated, immigrants from English-speaking countries showed a disproportionately large number of adult cases and this trend continued for the next few years. In 1958, almost all of the cases were in infants and young children born in Israel. These have been analysed according to the country of origin of the father.

For ages 0-6 months there was some increased susceptibility of children of North African parents (Table 12). When the age-groups (birth cohorts) were considered severally, differences were more marked. For the youngest group, born during 1958, children of North African parents were especially susceptible; this was even more marked for the 1957 cohort. At ages 3-4 years there was no effect of parental origin and the pattern was even reversed in the 5-6-year-olds, although the numbers are small. This is illustrated in Table 12 and Fig. 7. These differences were not related to differences in the acceptance of vaccination by the different ethnic groups (Nathanson et al., 1959).

An attempt was made to link these findings with family size as North African and Asian immigrant families averaged 5.3-5.4 members, compared with 4.4 and 4.6 respectively for parents of Israeli and European-American birth. Unfortunately, the sample of 93 cases where birth order was known was too unrepresentative to permit of statistical analysis.

TABLE 12
POLIOMYELITIS ATTACK RATES (PER 10 000 JEWISH POPULATION) BY AGE COHORT
AND FATHER'S PLACE OF ORIGIN, 1958

Age cohort	Israel	Asia	Africa	Europe- America	Total	Significance of differences
1952-53	8	1	1	6	3	Small numbers
1954-55	10	6	10	8	8	No significance
1956	16	20	35	21	24	P<0.05
1957	44	51	93	21	54	P<0.001
Jan. to June 1958	36	22	53	9	28	P<0.001
1952 to June 1958	19	14	29	11	17	P = 0.03

FIG. 7
STANDARD MORBIDITY RATIO (SMR)^a OF JEWISH
POLIOMYELITIS CASES IN ISRAEL, 1958,
BY AGE COHORT AND FATHER'S PLACE OF ORIGIN

^a Percentage of the mean cohort rate.

Clinical aspects

The clinical picture and problems of treatment of poliomyelitis in Israel in the past have been reviewed by Falk (1951), Marberg (1952), and recently by Rotem (1959) and Rotem et al. (1958).¹ In 1958 there were 53 deaths, giving a case fatality of 9.2% compared to 8%-14% in previous years. Clinical details were available for 533 of the 573 paralytic cases (Table 13); 73.5% were spinal, 12.2% bulbar and 4.5% bulbospinal. In 1950, 18.1% of all paralytic cases were bulbar and 27.3% bulbospinal (Yekutieli et al., 1955).

¹ A further review (unpublished) was submitted by Rotem as a working paper for the Technical Discussions held at the 1959 session of the WHO Regional Committee for the Eastern Mediterranean.

An unusual feature of the clinical pattern was the large number of cases with facial paralysis only. These comprised 11.8% of all cases, that is, nearly all the bulbar cases were of this type. The case fatality was highest (16%) under the age of 12 months, although bulbar and bulbospinal cases were relatively uncommon. Unfortunately, this age-group has the largest proportion of cases after two injections of vaccine and thus the effect of vaccine on fatality cannot be tested.

The clinical picture was unaffected by the father's country of origin and no effect of vaccination could be detected. The larger number of bulbar cases in the triply vaccinated children is possibly a product of higher age rather than immunity.

TABLE 13
PARALYTIC POLIOMYELITIS CASES BY AGE AND
CLINICAL PICTURE,^a 1958, IN JEWS AND NON-JEWS
(SHOWN IN PARENTHESES)

Age (years)	Spinal paralysis	Bulbar paralysis	Bulbo-spinal paralysis	Deaths ^b	Total
<1	119 (12)	6	8	27 (1)	160 (13)
1	129 (15)	28 (1)	8	13 (1)	178 (17)
2-6	106 (11)	30	7 (1)	9 (1)	152 (13)
Total	354 (38)	64 (1)	23 (1)	49 (3)	490 (43)

^a $\chi^2 = 16.36$; $P = 0.05$; 4 degrees of freedom. There are significantly fewer bulbar cases in children under 1 year.

^b There is a significant increase in deaths under 1 year; $P = 0.05$.

POLIOMYELITIS IN 1959

In 1959, the epidemic curve fell as dramatically as it had risen in 1958 (Fig. 1). There were 51 notifications, of which 36 fulfilled the established criteria. Altogether 33 of the cases were in children under 5 years of age (92%), two were in children 6 years old and one was in a recent immigrant of 20 years of age from America who had never been immunized. More than half the cases and all the fatalities were in children under 1 year of age (Table 14). The peak month of incidence was July and two cases were recorded after September. As may be seen from Table 15, poliovirus type 3 predominated with 13 cases, type 1 was isolated on five occasions, and type 2 twice only.

The total rate was 0.17 per 10 000, the lowest since 1948.

ANALYSIS OF VACCINE EFFICIENCY

Only paralytic cases are considered in the present analysis in view of the prevalence of other enteroviruses in Israel and the sources of error involved in a diagnosis of "non-paralytic poliomyelitis". Nearly every case was seen at one of three hospital centres. All the 1957 and 1959 cases and 531 of the 575 cases in 1958 were admitted for treatment. Each case was assessed by a clinician or team of clinicians with considerable experience, and blood and faeces were sent for virological and immunological studies from the majority. Following discharge from hospital a decision on diagnosis and further treatment was made by a committee of clinicians and the district medical officer. A questionnaire was completed and

TABLE 14
PARALYTIC POLIOMYELITIS CASES AND DEATHS
BY AGE, 1959

Age	Cases	Deaths
<6 months	8	1
6-11 months	12	1
1 year	6	0
2 years	3	0
3 years	2	0
4+ years	5	0
Total	36	2

TABLE 15
PARALYTIC POLIOMYELITIS CASES IN 1959
BY MONTH OF ONSET AND VIRUS TYPE

Month	No. cases	Poliovirus isolated ^a				Total
		Type 1	Type 2	Type 3	Negative	
Jan.	2	1	0	1	0	2
Feb.	3	1	0	0	1	2
March	3	0	0	2	1	3
April	1	0	0	0	1	1
May	4	0	0	3	1	4
June	5	1	0	2	1	4
July	11	2	1	2	3	8
August	5	0	0	2	2	4
Sept.	0	—	—	—	—	—
Oct.	0	—	—	—	—	—
Nov.	0	—	—	—	—	—
Dec.	2	0	1	1	0	2
Total	36	5	2	13	10	30 ^a

^a Viruses other than polioviruses were isolated in four cases (ECHO viruses in two of these) and two cases were not examined.

a copy sent for final review to the Poliomyelitis Advisory Committee of the Ministry of Health, the authors of this paper.

Efficiency of vaccine in 1957

Of the 57 paralytic cases recorded, 8 fell sick before the end of the vaccination campaign in May and only 20 of the remainder were of "campaign age" (Yekutieli et al., 1958). The analysis must therefore be restricted to these 20, although in view of the fact that their ages were 6-24 months and the "campaign age" children were 6-36 months old the population figures are not strictly applicable (Table 16). With these reservations and having regard to the small numbers, two injections of vaccine reduced the rate from 4.5 per 10 000 to 1.0 per 10 000, an efficiency of 78%. The three cases in the "1 injection" group are too few to permit of analysis. However, if the cases in the "no injection" and "1 injection" groups are combined, the resulting rate is 5.6 per 10 000, bringing the efficiency of two injections, compared with 0-1 injection, to 82%.

TABLE 16
POLIOMYELITIS IN CHILDREN OF "CAMPAIGN AGE",^a
MAY-DECEMBER 1957, IN RELATION
TO NUMBER OF VACCINE INJECTIONS RECEIVED

	No injections	1 injection	2 injections
No. cases	6	3	11
Population	13 354	2 171	110 464
Rate per 10 000	4.5	11	1

^a Aged 6 months to 3 years.

Efficiency of vaccine in 1958

As described above, the year 1958, in contrast to 1957, was an epidemic year with a national poliomyelitis rate of 2.9 per 10 000; 3.0 for the Jewish and 2.1 for the non-Jewish populations. The numbers of cases by population group and vaccination status are given in Table 17. Before making the analysis, it is necessary to standardize for a number of variables, as some of these (for example, age, geographical area and month of onset) may have a marked effect. The following factors were taken into account.

Demographic data. Although data on births during recent years may be said to be complete (96% take place in hospital), there were administrative delays in registration according to place of residence and local lists especially were incomplete in the age-group 0-1 year. Some 20% of the population changes its address annually and there may be considerable delay in registration of the new residence (although this is required by law). Similarly, the immigrant population figures were available for ages 0-15 years, without further break-down, and for first address only. Many immigrants are known to move in with friends or relatives soon after settling in the country, again with delayed registration of the new address.

Accurate knowledge of populations by age is, of course, necessary both for the calculation of rates and for the estimation of the numbers of unvaccinated children.

Vaccinated population. The numbers of children receiving vaccine from governmental sources is fairly accurately known, although even here gaps exist in the statistics of certain local authorities. An unknown number of children received vaccine from

private sources (usually relatives abroad) and the unimmunized population is thus smaller than that calculated (producing a rise in rate) and the population receiving two injections or more is larger (producing a fall in rate). Vaccination was continued throughout the epidemic so that the populations of vaccinated and unvaccinated children were continually changing. This is illustrated in Fig. 8, where the size of the 1957 age cohort with two injections of vaccine is seen to diminish throughout the period June-August as the third injections were given.

Cases were taken to have had one, two or three injections only if the injection had been given 14 days or more before the onset of the disease. Otherwise they could be considered to have been vaccinated within the incubation period and the efficacy of the particular dose would be doubtful. Populations were also computed from the number who had received the particular number of injections more than 14 days prior to the specified date.

Geographical considerations. As has been shown above, there were marked variations in the attack rate in different areas of the country. The southern region suffered an attack rate of 7.5 per 10 000 for the whole year compared to 1.5 for Haifa and 1.9 for Tel-Aviv (Table 10). Thus the "protective effect" of living in Haifa was 80% compared to, say, Ashkelon in the south. Since it cannot be proved that the vaccination rates were identical in these two areas for any specific age at any given time, calculations using their combined populations are inadmissible.

TABLE 17
PARALYTIC POLIOMYELITIS CASES BY
VACCINATION STATUS AND ETHNIC GROUP, 1958

Ethnic group	No. vaccine injections ^a				Total
	0	1	2	3	
Jews	144	33	203	149	529 ^b
Arabs	24	4	9	4	41
Others	2	0	1	0	3
Totals	170	37	213	153	573

^a Given at least two weeks before the date of onset.

^b Originally 531, but 2 cases were subsequently rejected as non-poliomyelitic.

FIG. 8
POLIOMYELITIS CASES OCCURRING DURING
THE PERIOD MAY-AUGUST 1958 AMONG THE 1957
AGE COHORT, SHOWING CHANGES IN VACCINATION
STATUS OF POPULATION

Effect of season. The chances of a child contracting poliomyelitis were greater in May and June than in January or October. As the year progressed the age of the child changed, and with it his chance of having been vaccinated (the vaccination schedule was not uniform for the whole country) and of having passed through a silent infection with subsequent immunity. For purposes of evaluation therefore, mean rates have been calculated for each month and only those of the epidemic peak (May-August) have been used.

Effect of age. It is evident from Table 2 and Fig. 5 that the age factor is of prime importance. Indeed, there is nearly a fivefold reduction at age 3-4 compared with age 1-2 and the "protective effect" of being 4 years compared to being 1 year old is equal to 88%. For purposes of comparison, therefore, vaccinated and non-vaccinated children must come from narrow age cohorts even though vaccination did cover most children between 6 months and 4½ years of age.

The most susceptible group is aged 6-18 months, that is, the cohort born in 1957 at the epidemic peak. This is also the group which had received two injections by this time. Were the vaccine 88% efficient at this age, then the rates in the 1957 cohort would be equal to those of the 1954 cohort. As it is less efficient than this, grouping of all children under 5 years shows paradoxically a higher rate in children who have had two injections compared with the unvaccinated group (Table 18).

TABLE 18
PARALYTIC POLIOMYELITIS CASES AMONG
ALL CHILDREN AGED 0-4^a BY VACCINATION STATUS,
MAY-AUGUST 1958

No. injections	Cases	Mean population	Rate per 10 000
0-1	123	69 200	17.8
2	203	44 850	45.3
3	125	147 950	8.4

^a Born July 1953-June 1958.

Race and virus type. As described above (see Table 9) there was a significant association between infections with poliovirus types 2 and 3 and paralytic poliomyelitis in non-Jews. The response of the minorities to the vaccination campaign was disappointing (see above), particularly in the rural areas, where only 50%-60% of candidates were brought for injection. These two facts explain the findings presented in Table 19, where a correlation is shown between the number of injections received and the type of virus isolated. The number of cases from which poliovirus types 2 and 3 and viruses of other etiology¹ were isolated was significantly higher for the 0-1 injection group as compared with the 2 or 3 injection group. Table 20 shows that this correlation is not statistically significant for the Jewish population.

Taking all these factors into account, it is clear that any analysis based on the total population or the whole country or a broad age band, even if feasible, would be inadmissible. Intensive analysis was therefore made of a defined area and the administrative districts of Jerusalem and Ashkelon were selected for this purpose.

¹ Coxsackie, ECHO and similar virus infections.

Vaccine efficiency in Jerusalem and Ashkelon districts. These two districts suffered from the highest attack rates of the whole country, 5.3 and 7.4 per 10 000 respectively (Fig. 4). Registration of the population and of vaccinees was accurate and orderly and there was an exemplary follow-up of each case. The population is mixed urban and rural and there was less likelihood of private sources of vaccine. Moreover, the progress of the epidemic was parallel in both areas.

In view of the effect of age on attack rate, the age-group 0-4 years was divided into two, the 1957 cohort (the most susceptible) and the remainder. These were analysed separately for the period May-August 1958 (the peak epidemic period), and the results are set out in Tables 21 and 22. Rates were calculated for each month on the basis of total cases and mean population of the specified vaccine group. For children born in 1957, two injections of Salk type vaccine conferred 58% protection under the most rigorous conditions.

Vaccine efficiency in the 0-4-year age-group, excluding the 1957 cohort, is set out in Table 22. There are only two cases in the doubly vaccinated group, too small a number for reliance to be placed on the efficiency figure of 73%. The figure of 97% efficiency for three injections is undoubtedly a result of the combined effects of vaccine and age, the latter possibly being the more important factor.

Effect of vaccination on clinical pattern of disease. Older children have been shown to have a significantly higher rate of bulbar paralysis (Table 13). This is the explanation for an apparent association of three injections of vaccine with bulbar paralysis in Table 23. Apart from this, within specific cohorts, no effect of vaccine on clinical picture could be proved.

The case fatality was highest among children with two injections, but, as explained in the footnote to Table 23, this is probably due to the age factor: the fatality was highest under 1 year of age.

There was no effect of vaccination status or of age on the duration of hospitalization.

"Provoking effect" of injections. Salk vaccine and diphtheria-tetanus-pertussis combined vaccine were given to most infants attaining the age of 5 months throughout the epidemic of 1958. A detailed analysis of the time factor and the site of paralysis in infants recently vaccinated—following the methods described by Hill & Knowelden (1950)—revealed complete absence of provoking effect. A group of malnourished infants, living in the Ashkelon area, the

region with the highest attack rate, had received intramuscular injections of an iron-dextran preparation (known to produce some local necrosis) at the time of the appearance of cases in the same villages. There was no provoking effect from this or from the frequent injections of penicillin that were given for various reasons.

Effect of vaccination in 1959

The small number of cases in 1959 precludes any accurate analysis of the effects of vaccination. It is noteworthy that 22 of the 36 cases and the two deaths occurred in infants who had received no or only one injection of vaccine (Table 24). Of 21 infants in the most susceptible age-groups (i.e., 6 months to 2 years) less than a quarter had received three or four injections compared to 76% of the population from which they came. This suggests protection of a very high order. In children over 12 months of age it is impossible to separate the effects of vaccination, of age-group and of experience of the 1958 epidemic in producing the low attack rate.

COMMENT

While the beginnings of the present epidemic wave in 1949 could be explained on the basis of mass immigration, poor sanitation and disrupted social conditions (Yekutieli et al., 1955), it is more difficult to account for its unusual persistence during the years 1950-56. During the period 1952-58 the immigrants came either from Europe and America (and accounted for a handful of adult cases) or from North Africa, where the age pattern of immunity mirrors that in Israel (Payne, 1958). The seasonal incidence in Israel with maximum susceptibility of infants aged $\frac{1}{2}$ -1 $\frac{1}{2}$ years means that each spring brings a new, unsalted, generation. Even in the pre-vaccine days, there were unexplained relative variations in the age-specific attack rate between the first and second years (Table 2). The 1957 drop in incidence affected all age-groups, not merely those vaccinated, and although 1958 should have brought a wider age span of susceptible infants, especially to type 1 virus, there was no change in the age pattern of cases. Similarly, the effects of the fall in incidence in 1959 are not yet capable of assessment.

In connexion with the unpredictability of the epidemic spread of poliomyelitis it might be noted that Cyprus, Jordan and Lebanon all showed a considerable drop in notifications in 1957 and, together with Syria and Iraq, these countries showed a rise in 1958.

TABLE 19
VACCINATION STATUS OF PARALYTIC CASES AMONG ALL ETHNIC GROUPS,
BY TYPE OF VIRUS ISOLATED, 1958

No. injections ^a	Poliovirus type 1	Poliovirus types 2 and 3 and others ^b	Negative	Total Examined	Not Examined	Total
0-1	130	23	31	184	23	207
2	156	5	34	195	18	213
3	99	5	27	131	22	153
Total	385	33	92	510	63	573

^a The association between the number of injections and the type of virus is highly significant, i.e., there are more viruses *not* of poliovirus type 1 in the immunized groups ($\chi^2 = 18.16$; $P = 0.001$; 4 degrees of freedom).

^b Mainly ECHO and Coxsackie.

TABLE 20
VACCINATION STATUS OF PARALYTIC CASES AMONG JEWS ONLY,
BY TYPE OF VIRUS ISOLATED, 1958

No. injections ^a	Poliovirus type 1	Poliovirus types 2 and 3 and others ^b	Negative	Total Examined	Not Examined	Total
0-1	122	14	28	164	13	177
2	149	4	33	186	17	203
3	96	5	27	128	21	149
Total	367	23	88	478	51	529

^a The association between the number of injections and the type of virus is not significant ($\chi^2 = 8.8$; $P = 0.07$).

^b Mainly ECHO and Coxsackie.

TABLE 21
POLIOMYELITIS IN THE 1957 COHORT,
JERUSALEM AND ASHKELON DISTRICTS,
MAY-AUGUST 1958 ^a

No. injections	Cases	Mean monthly rate per 10 000
0-1	13	59
2	43 ^b	25
3	0	0
Total	56	21

^a Efficiency of vaccine = $100 (1 - \frac{R_1}{R_2})\% = 58\%$,

i.e., 58% efficiency of two injections in same cohort, for same period in same geographical area. Control group is valid.

^b 8 cases occurred in children less than 14 days after the third injections. They are considered to have had only two injections.

TABLE 22
POLIOMYELITIS IN AGE-GROUP 0-4 YEARS, EXCLUDING
THE 1957 COHORT, JERUSALEM AND ASHKELON
DISTRICTS, MAY-AUGUST 1958

No. injections ^a	Cases	Mean monthly rate per 10 000
0-1	30	15
2	2	4
3	35	4.0
Total	67	6

^a Comparing 0-1 injection with 2 injections, efficiency = 73%, but the numbers are very small. Comparing 0-1 injection with 3 injections, efficiency = 73%; the probable influence of age should be taken into account here.

TABLE 23
CLINICAL TYPE OF POLIOMYELITIS AMONG JEWS AND NON-JEWS (SHOWN IN
PARENTHESES) BY VACCINATION STATUS, 1958 ^a

No. Injections	Spinal paralysis	Bulbar paralysis	Bulbospinal paralysis	Total paralysis	Deaths	Total
0-1	104 (26)	12 (1)	5 (0)	121 (27)	15 (2)	136 (29)
2	135 (9)	13 (0)	10 (0)	158 (9)	27 (1)	185 (10)
3	115 (3)	39 (0)	8 (1)	162 (4)	7 (0)	169 (4)
Total	354 (38)	64 (1)	23 (1)	441 (40)	49 (3)	490 (43)

^a The high association of bulbar cases with 3 injections of vaccine ($\chi^2 = 19.71$; $P = 0.01$) is due to the higher age of the children in this injection group. Apart from this there is no effect of vaccination on the clinical picture. The case fatality is highest in children with 2 injections ($\chi^2 = 12.03$; $P = 0.05$; 2 degrees of freedom), but this again is a product of age as fatality is highest in children under 1 year of age ($\chi^2 = 12.37$; $P = 0.05$; 2 degrees of freedom).

The constant infantile pattern of paralysis with little predilection for new arrivals or upper social classes does not fit in with the general experience of low infant mortality and higher age of susceptibility (Payne, 1955; Paul, 1958). It may be that the social stratifications are much less marked in Israel than in other countries but emerging differences are indicated by the higher ages of cases of European-American parentage residing in Tel-Aviv. Bernkopf and his co-workers (1957) found, in one housing estate, that cleanliness and family size seemed to influence the frequency of antibody occurrence. Families of Asian and African origin do tend to be larger than those from other countries but the data

on birth order of cases was insufficient to permit of the establishment of a significant correlation between family size and attack rate. The mean housing density index for the whole country was 2.4 persons per room in 1958 and even the higher economic groups would show crowding in the studies of Backett (1957) and Nathanson et al. (1959) and belong to social classes IV and V by these criteria in the paper of Benjamin & Logan (1953). For this reason as well as for theoretical considerations (Goffe & Parfitt, 1955), no attempt was made to limit the epidemic spread by quarantine measures (Davies, 1958), and unpublished studies showed wide dissemination of the virus at the time of the appearance of the first clinical case.

TABLE 24
POLIOMYELITIS CASES IN 1959 BY AGE AND
VACCINATION STATUS (DEATHS IN PARENTHESES)

Age	Number of vaccine injections				
	0	1	2	3	4
<6 months	6 (1)	2	—	—	—
6-11 months	7	2 (1)	3	—	—
1 year	1	—	—	3	2
2 years	1	1	—	—	1
3 years	—	—	1	1	—
4+ years	2	—	—	3	—
Totals	17 (1)	5 (1)	4	7	3

The difficulties in understanding the epidemicity of poliomyelitis in Israel were further enhanced during the period in which vaccine has been used. The incidence in 1957 and 1959 was too low to allow of statistical evaluation of the effects of vaccine. In 1958, the high attack rate should have permitted evaluation but analysis revealed a number of additional factors which further complicated the picture. The most important of these factors were the change in the prevalence of type 1 poliovirus, the lack of precise demographic data, uneven geographical distribution of cases and the effect of season on attack rate and immunity. Most important of all was the age pattern of the disease. Since the highest attack rate was in a very narrow age-bracket, changes in age alone had a great effect on susceptibility even within the one epidemic year 1958. Thus the analysis of the vaccine effect had to be limited to

a small geographical area (Ashkelon and Jerusalem) and a narrow age-group. Even so, as shown in Table 21, there were no cases in the 1957 cohort that had received three injections, making impossible comparisons between the group receiving no or one injection and that receiving three injections. Where three injections were given (Table 22), the age factor prevents separate evaluation of the effect of vaccine.

To all this must be added the variations in dose, route of injection and potency of the vaccine lots

used throughout the years. Early batches of vaccine, used in 1957, gave low conversion rates in children and only 0.3-ml doses were given intradermally. Subsequently, the dose was raised to 0.5 ml and again to 1.0 ml given subcutaneously, while the antigenicity of the vaccine was raised by a factor of 10-30 (Table 4). The introduction of high-potency vaccine in May 1958 came too late to affect the epidemic picture of that year but the indications are that it may well have assisted in bringing about the low incidence of 1959.

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RÉSUMÉ

En automne 1949, la poliomyélite qui n'avait jusqu'alors causé que des cas sporadiques en Israël, prit une allure endémo-épidémique. En 1950, une grave épidémie éclata, avec un taux de morbidité de 12,8 pour 10 000 habitants. Ce taux s'est maintenu assez élevé jusqu'en 1957, ne s'abaissant jamais en-dessous de 2,3 pour 10 000 habitants. 85-90% des cas se sont produits chez des enfants de moins de 5 ans, ce qui indique une solide immunité des groupes d'âge supérieurs. Le type 1 du poliovirus a prédominé jusqu'en 1956; en 1957 et 1959, les types 2 et 3 ont été les plus fréquents. Le type 1 a réapparu en 1958 — fait important pour l'épidémiologie de la poliomyélite en Israël et pour l'évaluation de l'efficacité des vaccins.

La vaccination par le vaccin inactivé de Salk, produit en grande partie en Israël, commença en janvier 1957, et fut appliquée plus spécialement au groupe d'âge le plus vulnérable (6 mois-3 ans). L'activité des premiers lots de vaccin étant faible et l'injection faite par voie intradermique — moins efficace que la voie sous-cutanée — le taux de conversion pour le type 1 ne dépassa pas

25%. Plus tard, des vaccins plus puissants, administrés par voie sous-cutanée ont assuré un taux de conversion de 71-95%.

L'épidémie de poliomyélite qui a éclaté en 1958 dans une population de jeunes enfants vaccinés a suscité un vif intérêt sur le plan international. C'était la première fois que l'occasion se présentait d'évaluer le degré de protection d'une population vaccinée exposée à une grave épidémie. Les auteurs rendent compte des observations faites. Le vaccin a assuré une certaine protection, mais pas si élevée que celle que l'on pouvait espérer d'après les résultats obtenus ailleurs sur des enfants plus âgés. Cet échec partiel peut s'expliquer en partie par les défauts des premières vaccinations, qui viennent d'être signalés, en partie par la prédominance du type 1 cette année-là, au contraire des années précédentes. Il est difficile aussi de séparer, pour l'analyse, le facteur vaccin du facteur âge, qui joue un rôle considérable, le fait pour des enfants d'avoir dépassé l'âge le plus critique, ne fût-ce que d'une année, étant en soi une forme de « protection ».

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