

THE POLIOMYELITIS IMMUNIZATION PROGRAMME IN SINGAPORE

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Infection by poliovirus is usually inapparent. Occasionally, there may be a minor illness with symptoms of fever, headache and gastrointestinal disturbance. This is the extent of the clinical picture in the majority of cases. However, in a small percentage of cases there is involvement of the central nervous system which is expressed clinically as either "aseptic meningitis" or "paralytic poliomyelitis". It is this latter syndrome with flaccid paralysis as a prominent feature followed by residual permanent disability that makes poliomyelitis a disease of public health importance.

For many years in the State of Singapore the incidence of paralytic poliomyelitis has been noted carefully (Lee, Lim and Tye, 1964). The disease is notifiable, and because of its rather alarming and distinctive features medical care is inevitably sought so that every case comes to the attention of the health authorities. The cases that might be missed are possibly those which are fulminating and succumb before a diagnosis is made; their number, however, must be insignificant.

Since 1959, all notified cases of paralytic poliomyelitis have been investigated and laboratory confirmation attempted in each instance. In this way, a clear picture of poliomyelitis in Singapore has been obtained. The epidemio-

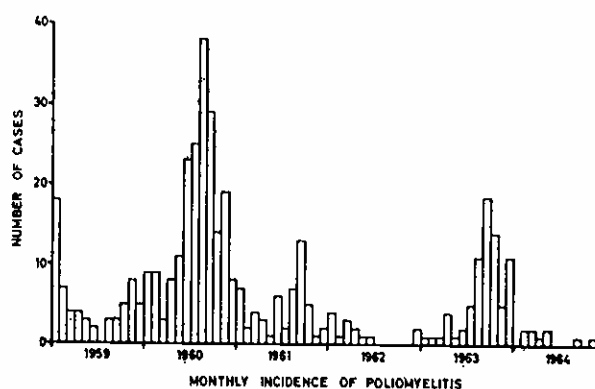


Fig. 1. Monthly incidence, by date of onset, of paralytic poliomyelitis in Singapore for the years 1959 — 1964.

logical pattern of poliomyelitis in Singapore is that of an endemic disease breaking out periodically in epidemic form. Children below 5 years of age were those most at risk, particularly those in the very young age-group of six months to two years. Poliovirus type 1 was responsible for the majority of cases and for the epidemic waves. Poliovirus type 3 was of minor importance and type 2 comparatively unimportant. (Lee, Lim and Tye, 1964). Figure 1 shows the monthly incidence of paralytic poliomyelitis, by date of onset, for the past six years, and Table I shows the serological types of the polioviruses isolated from notified cases.

TABLE I
VIRUSES ISOLATED FROM NOTIFIED CASES OF POLIOMYELITIS

RESULT	1959	1960	1961	1962	1963	1964	TOTAL
Poliovirus Type 1	19	111	11	4	39	5	189
Poliovirus Type 2	2	1	3	0	3	0	9
Poliovirus Type 3	11	15	8	2	1	1	38
Other cytopathogenic agents	6	8	8	0	2	0	24
Negative	22	59	20	5	24	4	134
No specimen	2	2	3	3	5	1	16
Total notified cases	62	196	53	14	74	11	410

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In 1958, there occurred an epidemic of poliomyelitis due to type 1 virus which extended into the early months of 1959, and involved over 400 cases. Oral poliovaccine was used for the first time on a mass scale in Singapore in an attempt to modify the course of the epidemic. The results were reported by Hale et al. (1959). Poliovaccine type 2 was fed to about 200,000 children to provide protection by interfering with the establishment of the epidemic virus type. An analysis of the data from this campaign showed that there was a substantial reduction in the risk of paralytic disease as a result of the vaccination (Knowelden, Hale, Gardner and Lee, 1961).

In 1960 a Committee appointed by the Singapore Government carried out a serological and faecal survey to assess the immune status of children and to study the results of the type 2 vaccination campaign. The findings were submitted in a Report to the Ministry of Health, Singapore (1961). The Committee recognised that poliomyelitis would increase unless active preventative measures were adopted and recommended a programme of immunization with oral poliovaccine for the control of poliomyelitis in the State. This programme was approved and executed by the Government's Public Health Division.

Monovalent oral poliovaccine was imported as vaccine concentrate and after dilution, made up into polyvalent packs containing either types 1 and 3 or types 1, 2 and 3 by the Department of Bacteriology of the University of Singapore. Magnesium chloride was incorporated in the diluted vaccine in molar concentration as stabiliser (Wallis and Melnick, 1961). Stocks of diluted vaccine were prepared for current requirements and stored frozen at -20°C . until issued to various clinics and immunization teams. The storage of the vaccine in the clinic refrigerators was at the temperature of 0° to 4°C . Although unfrozen vaccine stored in this way is stated to maintain its potency for at least six months, departmental instructions ensure that no vaccine in use was stored for more than three months, and as far as possible only a supply of vaccine for the period of six weeks was carried by a clinic. Mobile teams conveyed the vaccine in thermos flasks which were stored overnight in a central refrigerator.

The first phase of the poliomyelitis immunization programme began in March 1962. At Maternal and Child Health Centres, totalling 34 in the city and rural areas, one or two sessions per week were set aside for different types of immunization, and parents bringing their children for immunization against diphtheria, pertussis and tetanus were urged to accept poliovaccine as well. In practice, the procedure was very popular and there was little "sales resistance" to a vaccine that was given orally. The children served by the Maternal and Child Health Centres were mostly six years of age and below. By November 1962, 205,000 children constituting a coverage of approximately 60% of the age-group concerned had received two doses of trivalent, *i.e.*, types 1, 2 and 3, vaccine. The British Medical Research Council trials (P.H.L.S., 1961) had shown that three doses of trivalent vaccine gave good results, but it was decided to give initially only two doses of trivalent vaccine, three months apart. The immune response to this regime was studied in a group of children who had no antibody to all three poliovirus types prior to immunization. It was found that the conversion rate was only 50% for type 1 poliovirus, 98.5% for type 2 and 58.8% for type 3. Thus two doses of trivalent vaccine were inadequate since protection against type 1 and type 3 poliomyelitis was considered much more important epidemiologically than protection against type 2. Nevertheless, it was gratifying to note that the incidence of poliomyelitis in that year dropped to a new low figure of 14 and during the months of July to November not a single case of paralytic poliomyelitis was notified. It seemed reasonable to assume that this was to some extent the consequence of the vaccination campaign.

To complete the immunization, the children were advised to return for a further dose. The numbers that responded were 29,331 in 1963 and 17,891 in 1964 giving a total of 47,222 (23%) children who could be said to have completed their course of immunization begun in 1962.

The experience gained indicated a need to revise the vaccination schedule which was now altered to two doses of bivalent vaccine containing types 1 and 3 followed by one dose of trivalent vaccine. Since type 1 and type 3 polioviruses were responsible for the majority of cases it was considered desirable to immunize

with these types initially and to include these types even when immunizing with type 2 vaccine. Type 2 vaccine was omitted from the first two doses to increase the efficiency of immunization against types 1 and 3 since type 2 virus in a trivalent mixture tends to interfere with the immune response to the other types. It should also be noted that the rate of natural occurring enteroviruses is high in Singapore. About 20% of children at any time are excreting some type of enterovirus which could interfere with the establishment of vaccine virus and cause a failure of immune response. For this reason, repeated administration of vaccine is advocated.

The second phase of the immunization programme with the amended schedule was introduced in March 1963. This was the primary immunization of children in the first year of life. Infants in Singapore attend the Maternal and Child Health Centres for vaccination against diphtheria which is compulsory. In practice they are immunized against diphtheria, pertussis and tetanus simultaneously. Advantage is taken of their attendance to offer them oral poliovaccine which is accepted by the majority. The interval between doses is one month. The programme has now become routine, and Table II gives the number of children up to six years of age that were immunized with poliovaccine in 1963 and 1964.

Approximately 30,000 children in 1963 and 50,000 in 1964 may be regarded as having completed their primary course. This rate of immunization would be considered satisfactory, in view of the birth rate of 60,000 per annum in Singapore, if it is continued in future years. The totals for children who receive one or two doses include some of those who received three doses subsequently in that year, but also include those who for some reason or other failed to complete the course. The protection given to these children although not considered complete contributes significantly to the overall immunity of the population.

Under ideal conditions, the three-dose programme may be expected to confer protection against all three poliovirus types on every child so immunized. However, interference from naturally occurring enteroviruses, and other non-specific factors may in some instances prevent the acquisition of immunity. In consideration of this, a fourth dose was recommended as a "booster", generally to be given to children in the year following primary immunization. Introduced in 1964, the booster doses have attracted only relatively small numbers, and the returns are also shown in Table II.

Nearly 60,000 children about 7 years of age entered school for the first time in 1964.

TABLE II
ORAL POLIOVACCINE INOCULATIONS IN HEALTH CENTRES AND SCHOOLS

POLIOVACCINE	1963	1964	
	HEALTH CENTRES	HEALTH CENTRES	SCHOOLS
1st dose Types 1 & 3	54,594	51,841	33,640
2nd dose Types 1 & 3	39,339	50,518	29,471*
3rd dose Types 1, 2 & 3	31,008	49,893	—
4th dose Types 1, 2 & 3	—	8,455	—
3rd dose for 1962 campaign Types 1, 2 & 3	29,331	17,891	—
Total	154,272	178,598	63,111

* The 2nd dose in schools was of trivalent vaccine.

Many of these had been immunized in the 1962 campaign when they received two doses of trivalent vaccine. The Schools' Health teams who visited the schools to carry out diphtheria immunizations also inoculated with parental consent those children who had missed the 1962 campaign, with one dose of bivalent and one dose of trivalent vaccine. Nearly 30,000 school children were so immunized as shown in Table II which also gives the totals for children receiving the 3rd dose of the course commenced in 1962.

The implementation of the poliomyelitis immunization programme in all its aspects as described was accompanied by a marked decrease in the incidence of paralytic poliomyelitis during the past three years as seen in Figure 1, compared with the incidence in earlier years.

Table III gives the poliomyelitis incidence with the standardised case and death rates for

the past ten years. The primary data used for this table are the number of cases occurring according to the date of notification. Elsewhere in this paper cases are recorded according to date of onset since this may be of relevance when vaccination dates are also considered. The difference in approach accounts for some discrepancy in case incidence in some years because a case occurring at the end of the year may be notified in the following year.

In 1963, 74 cases of paralytic poliomyelitis were notified. Of these, 64 occurred as a minor epidemic in the latter half of that year, a grave disappointment in view of the encouraging returns of the preceding twelve months. Fifty-seven (77%) of the cases were children between six months and two years of age. Type 1 poliovirus was isolated from 39 cases, type 2 from three cases and type 3 from one case. It is reasonable to believe that the epidemic occurred

TABLE III
INCIDENCE* OF POLIOMYELITIS SINCE 1955 WITH
STANDARDISED CASE AND DEATH RATES

YEAR	1955	1956	1957	1958	1959
Cases	24	46	58	403	64
Deaths	3	1	6	13	4
Case Fatality	12.5%	2.2%	10.4%	3.2%	6.3%
Population	1,305,500	1,371,600	1,445,929	1,514,000	1,579,600
Cases/100,000	1.84	3.43	4.01	26.62	4.05
Deaths/100,000	0.23	0.07	0.42	0.86	0.25

YEAR	1960	1961	1962	1963	1964
Cases	197	57	14	68	19
Deaths	6	5	1	2	2
Case Fatality	3.1%	8.8%	7.1%	2.9%	10.5%
Population	1,634,100	1,687,300	1,732,800	1,775,200	1,820,000
Cases/100,000	12.06	3.38	0.81	3.83	1.04
Deaths/100,000	0.37	0.30	0.06	0.11	0.11

* According to date of notification.

in a population of susceptibles that had been built up in the interval between the 1962 campaign following which there were five months without case notifications and the beginning of the 1963 immunization programme.

It is pertinent to indicate that the notified cases include 11 (14.7%) who had received oral poliovaccine. Seven of them had received one dose and 4 had received two doses. The particulars of these cases together with the intervals between vaccination and onset of disease are given in Table IV. One other case who received one dose of vaccine on the day of onset has been omitted from our data. The outstanding fact was that no child who had received three doses of vaccine, the recommended primary course of immunization, contracted paralytic poliomyelitis, a very practical demonstration of the effectiveness of the immunization programme. This conclusion was further borne out in 1964 when out of 11 cases spread out through the year, only one child had received oral poliovaccine. Indeed, this child received two doses

of trivalent vaccine in 1962 and did not take the third dose.

A question which arises from the data presented in Table IV is whether any of the cases occurring in the vaccinees were attributable to vaccine virus that was "insufficiently" attenuated. Such a doubt is difficult to dispel in the individual case, and it is true that four of the cases who received only one dose of vaccine contracted paralytic poliomyelitis within the possible incubation period. However, until poliomyelitis has been eradicated from Singapore and the introduction of infection from elsewhere prevented, there must be occasionally cases in susceptible children who chanced to receive vaccine about the time of infection. The probability of such a coincidence occurring is very high in view of the large numbers of children being immunised. Fear that cases may be attributable to vaccine virus cannot be supported from the data presented. There is further the point that even if some of the cases were, indeed, caused by vaccine virus, they were very

TABLE IV
PARALYTIC POLIOMYELITIS CASES IN VACCINEES, 1963

Name	Sex	Age (Years)	Date of vaccination	Onset of Symptoms	Vaccination/Onset interval	Faeces Isolation
A.G.	F	4 - 4/12	19.4.63	28.4.63	9 days	Polio 3
T.K.H.	M	7/12	28.6.63	16.7.63	18 days	Polio 1
H.A.	M	1 - 10/12	10.7.63	28.8.63	49 days	Negative
A.G.H.	F	1 - 5/12	7.3.63	1.9.63	6 months	Coxs. A9
C.J.	F	24	7.9.63	17.9.63	10 days	No specimen
L.B.W.	F	1 - 9/12	12.9.63	25.9.63	13 days	Polio 1
L.S.K.	M	1 - 10/12	25.6.63	19.10.63	4 months	Polio 1
B.C.M.	F	2	16.4.62 7.7.62	23.1.63	6 months	Negative
N.S.K.	F	1 - 4/12	16.3.63 16.6.63	16.8.63	2 months	Polio 1
C.S.	M	1	Feb. 63 Mar. 63	7.9.63	6 months	Negative
L.M.H.	F	1 - 3/12	10.5.63 10.8.63	28.10.63	2 months	Negative

few compared to the number of cases that could have been expected to occur in the absence of general immunization with oral poliovaccine.

DISCUSSION

It is well known that many communicable diseases show declining rates as community standards of living are raised, quite apart from the influence of specific measures such as immunization. In regard to poliomyelitis, improvements in social economic conditions lead to reduction of immunization through natural infection and increasing hazard of large scale epidemic outbreaks. Thus, in Singapore, the epidemiological evidence indicates that conditions were being created when large scale outbreaks such as that which occurred in 1958 would inevitably recur in the absence of specific measures. The introduction of a vaccination programme has replaced immunization through natural infection with its risk of paralysis by artificial immunization with attenuated virus. Epidemics of poliomyelitis have been rendered unlikely and the annual incidence of disease is reduced to negligible numbers.

An important consequence of the fall in poliomyelitis incidence is on the work of the Infectious Diseases Hospital which takes care of patients and of the Orthopaedic Units of the General Hospital which undertake the rehabilitation of cases with residual disability. Somewhat less than half the patients have minor or no sequelae and are discharged as "cured" after one or two months hospitalization. The larger proportion of cases may stay in hospital for as long as six months or even for years. The management of a poliomyelitis case often extends from early childhood to adolescence. The effect of such a long separation of very young children from the home environment is extremely unhappy, and should be seen with comparative rarity in future. The Orthopaedic Units, hitherto, have had their attention almost entirely engaged by the treatment of recent cases that were in the immediate post-convalescent stage. With the reduction in the number of fresh cases, the Orthopaedic Units have now been able to turn their attention to old cases for more leisurely planned corrective and plastic surgical treatment.

It is clear that the cost and effort involved in the implementation of the poliomyelitis immunization programme has been justified by

the results. It is extremely difficult, however, to assess accurately what proportions of children in different age-groups have been immunised in the establishment of the population immunity to poliomyelitis. One way of estimating the degree of immunization performed is to consider the total amount of oral vaccine fed into the population. In 1963, vaccine was fed on more than 150,000 occasions, either of bivalent or trivalent vaccine which included type 1 and type 3 vaccine. Thus type 1 poliovaccine and type 3 poliovaccine were both given 150,000 times in 1963. The number of children who received vaccine is much less than this figure since most children take the vaccine more than once. There were 410,300 children in the age-groups up to six years on 30.6.63. This is the population age-group to which the immunization programme was directed. The corresponding figures for 1964, omitting those vaccinated in schools were 180,000 feeds of vaccine to a population age-group of 413,700 children up to six years on 30.6.64. Thus, the average annual rate of immunization, in the two years under consideration was 40,000 vaccine feeds per 100,000 children per year. The fact that many of these children received trivalent vaccine in 1962 and some even, type 2 vaccine in 1958 should also be taken into account.

Another approach in assessing what has been achieved in immunization is to consider the proportion of children who have received the full primary course of three doses. In 1964, 24,000 children below one year of age completed three doses. There were about 60,000 children of this age, so approximately 40% of children below one year of age completed the primary course of immunization against poliomyelitis. Some children for various reasons were not immunized in the first year of life as recommended but completed the schedule subsequently. Separate returns for the immunization of one-year-old children were not available for 1964 but returns for the first three months of 1965 showed that the number of one-year-old children who completed the primary course were 978, 807, and 1,095, respectively. There were 58,000 children of this age so the average monthly immunization rate was 1.7% and the annual immunization rate was 20%. If this 20% rate for one-year-old children is added to the 40% for children who were below one year in the previous year, an immunization rate of 60%

is obtained for this birth cohort before their second birthday.

As the immunization programme is continued into future years, the aim should be to complete primary immunization of children against poliomyelitis in the first year of life since the incidence of paralytic poliomyelitis is greatest in the age-group up to two years. The rates of immunization that have been achieved should be maintained if not surpassed. There is always the danger that public response may slacken as the "danger" of poliomyelitis appears to recede. Sustained effort in public health education and continued diligence of the staff of Health Centres in persuading parents to have their children immunized is the only way by which our population immunity so arduously acquired would be retained.

SUMMARY

After a careful study of prevailing epidemiological conditions regarding poliomyelitis in Singapore, a programme of immunization with oral poliovaccine was instituted for the control of the disease.

The programme began with a mass campaign in 1962 when children up to six years of age were inoculated with two doses of trivalent oral poliovaccine three months apart. Subsequently the children were advised to return for a third dose and 23% of children in the age-groups concerned completed the schedule of three doses.

In 1963, the programme was extended by the inauguration of primary immunization of children in the first year of life with two doses of bivalent (types 1 and 3) oral poliovaccine and one dose of trivalent vaccine in that order one month apart. At the same time, children attending school for the first time who had not previously received vaccine were also given one dose of bivalent and one dose of trivalent vaccine. The programme was continued into 1964.

Notifications of paralytic poliomyelitis has in consequence dropped dramatically. In 1962 there were 14 cases; in 1963, 74 cases; and in 1964, 11 cases. No child who had completed the primary immunization schedule of three doses contracted paralytic poliomyelitis. Seven cases in 1963 had received one dose and four

had received two doses of vaccine. In 1964, one of the cases had received two doses of vaccine.

It is calculated that in 1963, 150,000 administrations of vaccine either bivalent or trivalent were given to children up to six years of age. In 1964, the number was 180,000. The population of these age-groups in those years were, respectively 410,300 and 413,700, giving an average annual vaccination rate of 40,000 vaccine feeds per 100,000 children.

The rate at which young children in the first two years of life were being given the complete primary course of three doses of vaccine is calculated at 60%.

It is considered that the incidence of paralytic poliomyelitis can be kept at very low levels if the programme described is maintained.

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