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A survey of enteroviruses and adenoviruses in the faeces of normal children aged 0–4 years

A report of the Public Health Laboratory Service and the Society of Medical Officers of Health*

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INTRODUCTION

In 1957 and 1958 a survey of enteroviruses in the faeces of normal children aged under 5 years in England and Wales was made to determine the prevalence of polioviruses in the community before the full introduction of inactivated poliomyelitis (Salk) vaccine (Report, 1958; Spicer, 1961). The present survey, which was similarly designed and covered 110 local authority areas (Appendix B) was made to find out the prevalence of polioviruses after Salk vaccine had been in use for over 4 years. The survey lasted 13 months; it began on 1 June 1961, and ended on 30 June 1962, although a few specimens collected at the end of May 1961 and the beginning of July 1962 were included in the analysis.

Live attenuated poliomyelitis (Sabin) vaccine was introduced for routine immunization in place of Salk vaccine at the end of February 1962; it was therefore possible to study the distribution of enteroviruses in the community before and after Sabin vaccination began. The vaccine used was trivalent Sabin vaccine and it should be emphasized that it was given for routine immunization and not in a mass vaccination campaign. A preliminary account of the poliovirus findings was given by Galbraith (1964).

METHODS AND MATERIALS

The children

A weekly sample of the population under 5 years of age in the areas administered by the local authorities participating in the survey was obtained, and each child in the sample who co-operated in the investigation was examined once. The method of sampling was similar to that described in the report of the previous investigation (Report, 1958) the children being chosen at random from the birth register by medical officers of health or members of their health departments.

In each local authority area the weekly sample contained at least one child in each year of age, that is, a total of at least five children. After the sample was chosen,

* A full list of those taking part in the survey is given in Appendix A.

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the names of some additional children were selected from the register to replace any in the original sample who could not be contacted or for any other reason did not supply a specimen.

The specimens

Medical officers of health made arrangements for the collection of specimens. In most areas, a letter describing the objects and methods of the survey was sent to the parents of the children and their co-operation was invited. A visit to the home was then made by a health visitor or health inspector who discussed the investigation with the parents and instructed them in the collection of a sample of faeces. A specimen container was left in the household and when the specimen had been obtained it was either posted to the laboratory or taken there by one of the health department staff; in either case the specimen usually reached the laboratory within 24 hr. of collection.

Laboratory methods

It was not possible to standardize laboratory methods in the survey because of wide variation among the thirty-five participating laboratories in the facilities and staff available for the investigation.

The technique for the examination of specimens in cell cultures described in the report of the previous survey (Report, 1958) was used in the present investigation but laboratories differed in certain details. In about two-thirds of laboratories two tubes of each type of cell culture were used and in the other third only one tube was used; the volume of faecal extract inoculated into the tubes in different laboratories ranged between 0·1 and 1·0 ml. In all laboratories the tubes were observed daily for cytopathic effect for at least 7 days, and the viruses isolated were identified by the use of specific antisera prepared by the Standards Laboratory for Serological Reagents, Colindale. Unidentified viruses were investigated further in the Virus Reference Laboratory, Colindale. The strains of poliovirus isolated were not classified into wild and vaccine strains, but it is probable that all those isolated before the introduction of Sabin vaccine were wild strains and those isolated after this were nearly all vaccine strains.

Most specimens were examined in newborn mice. Litters less than 48 hr. old were inoculated with between 0·01 and 0·03 ml. of faecal extract and examined daily for 12–14 days: in most laboratories the litters were inoculated subcutaneously but in some the intracerebral route was also used. Material from mice showing evidence suggestive of Coxsackie A virus infection was sent to the Public Health Laboratory, Epsom, for identification of the virus.

The records and analysis

A record card was completed for each child who submitted a specimen. Completion of the cards was begun in public health departments where the following information was provided: (1) name of local authority; (2) name, sex and date of birth of the child; (3) date of collection of specimen; (4) whether the child was one of the original sample chosen from the birth register or was one of the additional

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children selected as replacements; (5) whether or not the child had at any time received poliomyelitis vaccine, Salk and Sabin vaccines being recorded separately. The cards were sent to the laboratory with the specimens and when the laboratory results were available these were entered on the cards which were then forwarded to the Epidemiological Research Laboratory. Here they were checked to ensure that the required information had been given and the data were then summarized in a simple code on the right-hand edge of each card so that in the analysis the cards could be easily read and sorted.

RESULTS

In all, 25,600 children were examined, 13,194 of whom were males, 12,403 females and in three the sex was not recorded. This was a 3·9 % sample of the population less than 5 years of age in the survey areas recorded in the census of April 1961. The size of the sample was greater in children aged less than 3 years, 4·0 %, than in children aged 3 and 4 years, 3·7 %. This was probably because older children were more difficult to contact than younger children as was found in the previous survey (Spicer, 1961).

Table 1. *Number of specimens examined and types of laboratory examination*

Type of laboratory examination	No. of specimens examined
Total all types of examination	25,600
Tissue culture	
Total	25,589
HeLa cells	17,926
Monkey kidney cells	25,112
Human amnion	4,672
M.K.2	917
Human thyroid	707
H.Ep.2	438
Human embryonic kidney	401
Human liver	23
Human lung	4
Newborn mice	17,596

Of the 25,600 specimens, 25,589 were examined in tissue culture and 17,596 in newborn mice (Table 1). One or more different types of viruses and pathogenic bacteria were isolated from 2747 (10·7 %) of the specimens; 2035 (7·9 %) specimens were positive for viruses alone and 26 of them contained two different viruses; 651 (2·5 %) were positive for pathogenic bacteria alone and 10 of them contained two different bacteria; 61 (0·2 %) were positive for both viruses and pathogenic bacteria.

The total isolation rates per cent of each virus are given in Table 2. The unidentified agents recorded in the table are not included in the remainder of the analysis. There was no significant difference between the proportion of positive specimens from children in the original random sample and the proportion from

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children who were selected as replacements. The two groups of children, the random sample and the replacements, are therefore considered together in the results.

The isolation rate of polioviruses before Sabin vaccination began was 0·86% but for comparison with the results of the previous survey, in which examinations were made in HeLa cells only, it is necessary to express the number of poliovirus isolations in HeLa cells—117—as a proportion of all HeLa cell examinations—13,159, that is 0·89%. The isolation rate for the corresponding time of year in the previous survey was also 0·89%.

Table 2. *Viruses isolated and proportion of specimens positive*

	Specimens			
Virus	Examinations in	No. examined	No. and percentage positive	
Poliovirus (June 1961–Feb. 1962 before Sabin vaccination)	Cell culture	18,209	156	0·86
Poliovirus (March 1962–July 1962 after Sabin vaccination)		7,380	389	5·27
Adenovirus		25,589	128	0·50
Echovirus		25,589	278	1·09
Coxsackie B virus		25,589	196	0·77
Unidentified cytopathogenic agents		25,589	60	0·23
Coxsackie A virus	Newborn mice	17,596	894	5·08
Unidentified agents pathogenic to newborn mice		17,596	21	0·12

Polioviruses, both before and after Sabin vaccination began, Coxsackie B viruses and echoviruses were isolated proportionately more often in monkey kidney cells than in HeLa cells; the reverse was true of adenoviruses. The highest isolation rates were obtained when both types of cells were used. Coxsackie B viruses were isolated infrequently in newborn mice and only three specimens were positive in newborn mice when cell cultures were negative. There was a higher isolation rate of echoviruses in human amnion than in monkey kidney cells, but most of the isolations were made in monkey kidney cells because these cells were used most often (Table 1). The isolation rates of these viruses isolated in cell culture were calculated, the number of specimens examined in all types of cell being taken as the denominator, so that all positive specimens could be included irrespective of the type of cells in which the isolations were made. This simplified the presentation of the results and gave isolation rates which differed little from rates calculated separately for each type of cell. The isolation rates of Coxsackie A viruses were based upon the number of specimens examined in newborn mice, but in the analysis by virus type the isolation rates of virus A 9 were calculated, using the number of specimens examined in monkey kidney cells as the denominator, because this virus type was isolated most frequently in this type of cell.

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Double infections

The 26 specimens from which two viruses were isolated included 10 from which poliovirus and Coxsackie A virus were isolated. Seven of these double infections occurred before and three after the introduction of Sabin vaccination. It was not possible to assess the statistical significance of the association in the same specimen of different viruses because the number of double infections was too few.

There did not appear to be any relationship between the isolation of viruses and bacteria. There were too few double infections with viruses and salmonellae or shigellae to enable any conclusion to be drawn on the significance of their association. There were 42 specimens positive for viruses and enteropathogenic *Escherichia coli*, but none of the viruses occurred together with this bacterium more often than would be expected by chance.

Table 3. *Isolation of viruses in age groups*

	Percentage of specimens positive						
	Poliovirus before Sabin vaccination began*						
Age (years)	All children	Salk vaccinated	Not vaccinated	Coxsackie A virus	Coxsackie B virus	Echovirus	Adenovirus
Under 1	0·77	0·42	0·82	4·15	0·62	0·96	0·89
1	0·93	0·53	2·83	6·45	0·85	1·32	0·48
2	1·00	0·80	2·49	5·73	0·75	1·06	0·46
3	0·86	0·82	1·31	4·38	0·92	1·05	0·38
4	0·72	0·75	0·37	4·56	0·71	1·06	0·22
Total all ages	0·86	0·71	1·22	5·08	0·77	1·09	0·50

* June 1961 to February 1962.

Sex and age

There was no significant sex difference in the isolation rates of any of the viruses. There was no significant age variation in the isolation rate of polioviruses before Sabin vaccination began, but if the children who had not received Salk vaccine are considered alone there were striking differences among age groups (Table 3). The isolation rate was low in children less than 1 year of age, rose in the 1- to 2-year age group and then fell progressively with increase in age. The other enteroviruses showed a similar pattern, which was most noticeable with Coxsackie A viruses. The age distribution of adenoviruses was different; the isolation rate was highest in children less than 1 year of age and then declined steeply with increase in age.

Area and season

The laboratories and local authorities were grouped together in seven survey areas (Appendix B and Fig. 1). There were statistically significant variations in the isolation rates of each virus among these areas (Table 4). The variations between areas may have been due partly to differences in laboratory methods, but they

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Fig. 1. Participating laboratories and survey areas.

Table 4. *Isolations of viruses in survey areas*

Survey area	Percentage of specimens positive: Poliovirus before Sabin vaccination began* Type 1	Type 2	Type 3	Coxsackie A virus	Coxsackie B virus	Echovirus	Adenovirus
North	0·88	—	0·42	3·77	0·76	1·87	0·50
East Midland	0·12	—	0·52	5·10	0·12	2·17	0·06
West Midland	0·44	0·12	0·40	5·31	0·60	0·92	1·06
East Anglia	0·16	—	0·08	3·63	0·54	0·54	0·19
London	0·17	—	0·09	6·19	1·01	0·39	0·26
South-east	0·10	0·10	0·19	5·29	1·07	0·67	0·57
South-west	2·17	0·42	0·16	6·03	1·41	1·45	0·97
Total all areas	0·51	0·08	0·27	5·08	0·77	1·09	0·50

* June 1961 to February 1962.

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were probably due also to true regional variations in prevalence, because different types of the same virus showed different distributions by area.

The isolation rates of all viruses were higher in urban areas than in rural areas, and most of them fell progressively from county boroughs to municipal boroughs and urban districts to rural districts. The differences for polioviruses before the introduction of Sabin vaccine, as well as adenoviruses and echoviruses were statistically significant but for Coxsackie A and B viruses they were not. Nevertheless, the similar urban to rural gradient seen with all viruses suggests that they were all more prevalent in towns than in the country. The difference in the isolation rate of poliovirus between county boroughs and other types of local authority was greater in children under 2 years of age than in older children, suggesting infection at an earlier age in the densely populated areas.

Table 5. *Isolations of viruses in 4-weekly periods*

Four-weekly period and calendar month	Percentage of specimens positive				
	Poliovirus	Coxsackie A virus	Coxsackie B virus	Echovirus	Adenovirus
1961					
17–20 May	1·00	4·55	—	—	—
–24 June	0·65	6·95	0·22	1·20	0·65
–28 July	1·11	7·43	0·61	0·95	0·39
–32 Aug.	0·90	9·15	1·55	0·75	0·55
–36 Sept.	0·94	8·10	0·89	1·34	0·84
–40 Oct.	0·48	7·86	1·30	2·55	0·10
–44 Nov.	1·02	8·32	1·74	2·13	0·29
–48 Dec.	1·47	5·36	1·42	1·47	0·34
–52	1·18	2·96	0·62	1·73	0·56
1962					
1–4 Jan.	0·40	1·34	0·34	0·91	0·23
–8 Feb.	0·28	0·97	0·28	0·77	0·77
Sabin vaccination began					
–12 Mar.	0·89	1·44	0·28	0·17	0·50
–16 Apr.	3·37	1·36	0·41	0·36	0·71
–20 May	6·63	2·28	0·06	0·18	0·36
–24 June	9·26	2·10	0·28	0·48	1·04
–28 July	9·30	3·08	0·52	0·52	0·39
Total	2·13	5·08	0·77	1·09	0·50

The isolation rates of viruses in 4-weekly periods are shown in Table 5. The rate for polioviruses increased strikingly after the introduction of Sabin vaccination. Coxsackie A and B viruses and echoviruses were more frequently isolated in the summer and autumn than in other seasons. The variations in the isolation rates of adenovirus with season were not statistically significant.

Poliomyelitis vaccination history

The isolation rate of polioviruses from Salk vaccinated children was less than that from unvaccinated children in the period before Sabin vaccination began. After this the relationship was reversed, the isolation rate being higher in Salk

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vaccinated than in unvaccinated children (Table 6). The isolation rates of Coxsackie viruses A and B, echoviruses, salmonellae, shigellae and enteropathogenic *Escherichia coli* were unrelated to the history of Salk vaccination. Adenovirus isolations were more frequent in unvaccinated children than in Salk vaccinated children but this was due to the age distribution of adenovirus infections, the isolation rate being highest in children under 1 year when most of them were unvaccinated.

Table 6. *Isolations of poliovirus by type in relation to vaccination history before and after Sabin (trivalent vaccine) vaccination*

Vaccination history of children	Percentage of specimens positive			
	Total	Type 1	Type 2	Type 3
June 1961–February 1962 before Sabin vaccination				
Salk	0·71*	0·39	0·07	0·25
Not vaccinated	1·22*	0·80	0·10	0·32
Total	0·86	0·51	0·08	0·27
March 1962–July 1962 after Sabin vaccination				
Salk	3·71†	1·14	1·14	1·77
Sabin	59·26	27·16	37·04	35·80
Salk and Sabin	66·89	27·15	23·84	47·02
Not vaccinated	2·54†	0·44	1·27	0·93
Total	5·27	1·76	2·03	2·83

Many of the specimens collected after the introduction of Sabin vaccine (February 1962) contained more than one poliovirus type.

* Difference 0·51 % Standard error of difference 0·17.

† Difference 1·17 %. Standard error of difference 0·48.

The isolation rate of poliovirus in Salk vaccinated children varied little between age groups but in unvaccinated children was highest at 1 year and then fell with increase in age (Table 3). Thus, the difference in isolation rates between Salk vaccinated and unvaccinated children was highest in the 1-year age group, that is soon after they had been vaccinated, and it became less with increase in age and increase in the length of time after vaccination. In the 4-year age group there was no significant difference but the figures are too small to permit any conclusions.

Virus isolations by type

Before the introduction of Sabin vaccination Type 1 poliovirus was the most prevalent virus type. It was isolated most frequently in the north and south-west —areas in which outbreaks of Type 1 poliomyelitis occurred during the survey. Type 3 virus, which was less prevalent, was more common in the east midlands than elsewhere in the country (Table 4).

After Sabin vaccination began Type 3 virus became the most prevalent and Type 1 virus the least prevalent (Table 6). This was most evident in children who had received Sabin vaccine after previous Salk vaccination or who had not been vaccinated.

The isolations of Coxsackie A and B viruses, echoviruses and adenoviruses by

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types are shown in Table 7. The distribution of each virus type by sex, age, season and type of local authority was similar to that described for all types of the virus together. The geographical distribution by type showed considerable variations, different types being common in different parts of the country at the same time, but there was no evidence of spread of types from one area to another.

Table 7. *Isolations of viruses by type*

Virus type	Number and percentage of isolations							
	Coxsackie A virus		Coxsackie B virus		Echovirus		Adenovirus	
1	1	0·1	8	4·1	21	7·6	37	28·1
2	195	21·8	36	18·4	4	1·4	44	34·4
3	33	3·7	12	6·1	3	1·1	7	5·4
4	184	20·6	91	46·4	—	—	1	0·8
5	123	13·8	41	20·9	1	0·4	20	15·6
6	184	20·6	8	4·1	56	20·1	1	0·8
7	1	0·1	—	—	11	4·0	1	0·8
8	10	1·1	—	—	2	0·7	—	—
9	87	9·7	—	—	46	16·5	1	0·8
10	74	8·3	—	—	—	—	1	0·8
11	—	—	—	—	29	10·4	—	—
12	1	0·1	—	—	4	1·4	—	—
13	—	—	—	—	7	2·5	—	—
14	—	—	—	—	51	18·3	1	0·8
15	—	—	—	—	—	—	3	2·3
16	—	—	—	—	4	1·4	—	—
17	—	—	—	—	3	1·1	1	0·8
18	—	—	—	—	3	1·1	—	—
19	—	—	—	—	8	2·9	—	—
20	—	—	—	—	1	0·4	—	—
21	1	0·1	—	—	6	2·2	9	7·0
22	—	—	—	—	6	2·2	—	—
25	—	—	—	—	7	2·5	—	—
28	—	—	—	—	1	0·4	—	—
Frater	—	—	—	—	4	1·4	—	—
Total all types	894	100	196	100	278	100	128*	100

* In two the type was not recorded.

DISCUSSION

The survey demonstrated that enteroviruses and adenoviruses were often present in the faeces of normal children under 5 years of age, over 8% of all specimens being positive. The prevalence of these viruses varied with sex, age, geographical area, type of local authority and season. The results were similar to those of the previous survey in this country (Report, 1958; Spicer, 1961; Gamble, 1962) and were in accord with those of studies of enterovirus infections in Czechoslovakia (Žáček *et al.* 1962), Hungary (Dömök, Molnár, Jancsó & Dániel, 1962) and the United States (Cole, Bell, Beeman & Huebner, 1951; Honig *et al.* 1956; Melnick, Walton, Isacson & Cardwell, 1957; Gelfand, 1959; Gelfand, Holguin, Marchetti & Feorino, 1963).

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Dalldorf & Weigand (1958) reported experiments on monkeys in which paralytic disease followed double infection with attenuated poliovirus and Coxsackie A virus, but neither virus alone produced paralysis. It is possible that a similar summation of the effects of two non-interfering enteroviruses might take place in human beings (Meers, 1965). It is of interest, therefore, that in this survey of healthy children ten double infections with poliovirus and Coxsackie A virus were found. In seven of these the polioviruses were almost certainly wild strains because the specimens were collected before the introduction of Sabin vaccination.

The geographical distribution of the viruses isolated (Table 4) confirms the findings of previous studies that their prevalence varies between areas (Gelfand, 1961; Dömök *et al.* 1962). Interference between poliovirus and Coxsackie B virus was demonstrated by Dalldorf & Albrecht (1955), but in this survey there did not appear to be any relation between the isolation rates of these two viruses either geographically or in time.

All the echovirus types isolated in the survey (Table 7) were isolated also from persons with symptoms in England and Wales in the years 1959–63. Echovirus types 6, 9 and 14 were the most frequently isolated types in the survey, and these types predominated in clinical specimens in 1961 and 1962 (Peckham, 1964). Coxsackie B virus Types 2, 4 and 5 were the most frequently isolated types in the survey and also from clinical specimens (Vernon, 1964). The type distribution of Coxsackie A virus isolations from patients was not the same as in this survey, Type A 9 being found most frequently (Vernon, 1964), probably because few clinical specimens were examined in newborn mice. Adenovirus Types 1, 2 and 5 were the types most often isolated. This was to be expected because these types are commonest in children and usually associated with symptomless infection (Pereira, 1959).

Salk vaccination

Although Fox, Gelfand, LeBlanc & Rowan (1958) found no evidence that Salk vaccination had any effect on virus excretion during a subsequent poliovirus infection, more recent studies have shown that a high serum content of artificially induced antibody diminishes the frequency, amount and duration of excretion (Dick *et al.* 1961; Howe, 1962; Henry *et al.* 1963; Dane, 1964). The results of this survey are in keeping with these findings.

It is probable that Salk vaccination limits the spread of poliovirus in the community by diminishing faecal and pharyngeal excretion of virus on subsequent infection (Marine, Chin & Gravelle, 1962) and thereby protects unvaccinated persons as well as the vaccinated. Epidemiological evidence for this community effect of Salk vaccine was reported by Gard (1961) in Sweden and by Stickle (1964) in the United States. More recently in Sweden, Gard (1964) reported the complete elimination of polioviruses as a result of a systematic campaign in which Salk vaccine was given to a high proportion of the population.

In England and Wales in 1961, 5 years after Salk vaccination began, this community effect was not evident. The incidence of poliomyelitis in 1961 was greater than in the previous year (Report, 1961); furthermore, the results of this survey

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show that the prevalence of polioviruses in the community was the same in 1961 as it was 3 years before in the previous survey.

Sabin vaccination

There were two findings of importance to the field study of the safety of Sabin vaccine (Galbraith, 1963). First, the geographical distribution of polioviruses by type before Sabin vaccine was introduced showed that, whereas Type 1 virus was most prevalent in the areas where small epidemics occurred—the north and the south-west—Type 3 virus was most prevalent in other areas. When Sabin vaccination began, therefore, vaccine-associated cases of Type 3 poliomyelitis would by chance be more likely to occur in the non-epidemic areas than in the epidemic areas and the reverse would be true of Type 1 poliomyelitis. Clearly, it would have been a mistake to exclude the epidemic areas from the study and consider only the parts of the country in which vaccine-associated cases of Type 3 poliomyelitis would be expected to be more common. Secondly, Type 3 poliovirus became the most prevalent virus type after the introduction of Sabin vaccine (Table 6). This finding was reported also by Gelfand *et al.* (1963) after mass immunization with trivalent vaccine and it was noted in vaccine trials (Report, 1962; Perkins, Yetts & Gaisford, 1963) that Type 3 virus was excreted more frequently and for longer periods than either Type 1 or Type 2 virus. Thus in cases of paralytic disease following vaccination with trivalent Sabin vaccine a high isolation rate of Type 3 virus would be expected and would not indicate that the disease was caused by this virus.

The isolation rate of poliovirus after Sabin vaccination was introduced was higher in Salk vaccinated children than in unvaccinated children (Table 6). The reason for this is not clear, but it was probably due to intrafamilial spread of vaccine virus. The families that had accepted Salk vaccine for one child, would be likely to accept Sabin vaccine, when it became available, for a younger child; whereas a family that had not accepted Salk vaccine for one child would be unlikely to accept Sabin vaccine for another. Thus it is probable that the Salk vaccinated children were more likely to have been in contact with Sabin vaccinated siblings than the unvaccinated children.

In the study of Gelfand *et al.* (1963) mass immunization with trivalent attenuated vaccine caused a large temporary fall in the prevalence of wild enteroviruses. Sabin vaccine was used for routine immunization only in our survey and its introduction had no striking effect, but the lower isolation rates of Coxsackie A and B viruses and echoviruses in May and June 1962 than in the same months of the previous year may have been due to the vaccine.

SUMMARY

In a survey of enterovirus and adenovirus excretion in normal children in 1961–62, 25,600 faecal specimens were examined, 25,589 of them in cell culture and 17,596 in newborn mice.

Polioviruses were isolated from 156 (0·86 %) specimens before Sabin vaccination was introduced in February 1962 and from 389 (5·27 %) specimens after this.

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Coxsackie A viruses were isolated from 894 (5·08%) specimens, Coxsackie B viruses from 196 (0·77%), echoviruses from 278 (1·09%) and adenoviruses from 128 (0·50%).

The isolation rates of these viruses varied with sex, age, geographical area, type of local authority area and season.

The isolation rate of polioviruses before the introduction of Sabin vaccination was the same as in a previous survey carried out in 1957–58, although the rate was lower in Salk vaccinated children than in unvaccinated children. After Sabin vaccination began the isolation rate increased and Type 3 virus replaced Type 1 virus as the most prevalent virus type.

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APPENDIX A

The following virologists and bacteriologists took part in the survey: Drs J. A. Boycott, C. M. Patricia Bradstreet, F. A. J. Bridgwater, H. R. Cayton, D. R. Christie, Suzanne Clarke, G. T. Cook, D. G. Davies, J. M. S. Dixon, Lynnette M. Dowsett, A. D. Evans, A. L. Furniss, D. R. Gamble, E. H. Gillespie, M. H. Hambling, L. A. Hatch, R. J. Henderson, H. D. Holt, K. E. A. Hughes, M. H. Hughes, J. E. Jameson, W. H. Jebb, A. C. Jones, W. F. Lane, L. A. Little, G. B. Ludlam, F. O. MacCallum, E. M. Mackay-Scollay, A. D. Macrae, Hélène J. Mair, N. S. Mair, P. G. Mann, B. P. Marmion, E. R. Mitchell, T. D. F. Money, B. Moore, Marguerite S. Pereira, R. Pilsworth, Pauline M. Poole and L. Robertson, Prof. D. T. Robinson, Drs Mary O. Roebuck, W. Ryan, J. A. Rycroft, B. R. Sandiford, A. J. Kingsley Smith, C. E. D. Taylor, Joan Taylor, Prof. Scott Thomson, Drs J. O'H. Tobin, R. L. Vollum, G. Bruce White, J. E. M. Whitehead, Margaret A. Wilson, A. E. Wright.

The following medical officers of health and their staffs co-operated in the survey and undertook the task of collecting faeces specimens from a sample of children in their areas: Drs B. A. Astley-Weston, L. D. Bailey, J. H. Baines,

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E. Bebbington, P. M. J. Bobbett, W. G. Booth, J. W. Bowen and W. Bowen-Owen, Prof. D. B. Bradshaw, Drs H. Bryant, H. S. Bury, T. M. Clayton, J. S. Cookson, A. R. Darlow, G. Dison, O. C. Dobson, William Dodd, R. J. Dodds, F. H. M. Dummer, M. L. Dunlop, J. V. Dyer, R. M. Dykes, A. Elliott, J. F. Galloway, W. A. Glen, R. A. Good, I. Gordon, A. R. Graham, H. F. Green, E. Grundy, W. C. Harvey, R. C. Holderness, A. C. Howard, W. D. Hyde, E. D. Irvine, C. Ive, D. J. Jones, R. Arnallt Jones, T. Jones, J. D. Kershaw, S. Leff, Mary Lennox, F. D. M. Livingstone, J. Stevenson Logan, W. D. H. Macfarland, A. C. Mackenzie, J. Maddison, K. N. Mawson, D. F. Morgan, R. B. Morley-Davies, H. Morrison, J. B. Morwood, B. J. L. Moss, J. R. Murdock, L. F. McWilliams, P. J. O'Connell, G. M. O'Donnell, W. S. Parker, D. E. Parry-Pritchard, D. S. Pickup, J. R. Preston, J. L. Rennie, G. M. Reynolds, P. G. Roads, Llywelyn Roberts, H. D. H. Robinson and R. M. Ross, Prof. A. B. Semple, Drs C. L. Sharp, V. D. N. Shaw, E. T. Shennan, D. A. Smyth, L. Spencer Stephens, J. W. Starkey, R. A. Stenhouse, E. W. Caryl Thomas, G. C. K. Thompson, J. F. Warin, D. W. Wauchob, R. C. Webster, P. Westcombe, C. Robertson Wilson, R. C. Wofinden, J. L. M. Wood and A. Yarrow.

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Public Health Laboratories and Local Authorities taking part in the survey

Survey area and Registrar-General's region	Laboratory	Local Authority: County Borough	Local Authority: Municipal Borough or Urban District		Local Authority: Rural District
orth ngland nd North Vales, I I, X, VIII Wales 2)	Carlisle Chester Conway Leeds Liverpool Preston Sheffield Wakefield	Blackpool Carlisle Chester Leeds Liverpool Sheffield Wakefield	Colne Conway Darwen Fleetwood	Llandudno Lytham St Annes Nelson	—
ast lidland, II	Leicester Nottingham	Leicester Nottingham	Beeston and Stapleford	Carlton Loughborough	—
est lidland X	Birmingham Coventry Hereford Shrewsbury Stafford Worcester	Coventry Dudley Smethwick West Bromwich Wolverhampton Worcester	Droitwich Evesham Hereford Leamington Spa Malvern Nuneaton	Redditch Rugby Shrewsbury Stafford Sutton Coldfield Wednesfield	Droitwich Evesham Pershore Rugby Upton-on-Severn
ast Anglia, IV	Bedford Chelmsford Ipswich Luton Norwich Southend	Norwich Southend	Ampthill Bedford Benfleet Biggleswade Brentwood Canvey Island	Chelmsford Clacton Colchester Ilford Kempston Luton Rayleigh	Ampthill Bedford Biggleswade Rochford
ondon, V	Colindale Epsom	—	Beddington and Wallington Caterham and Warlingham Coulsdon and Purley Ealing Edmonton Enfield Epsom and Ewell Esher Feltham Friern Barnet Harrow Hayes and Harlington	Malden and Coombe Mitcham Ruislip and Northwood Southgate Sunbury-on-Thames Surbiton Twickenham Uxbridge Wembley Willesden Wood Green Yiewsley and West Drayton	—
uth-east ngland, , VI	Brighton Guildford Maidstone Oxford Portsmouth Winchester	Brighton Oxford Portsmouth	Andover Beckenham Bromley Chatham Eastleigh	Gillingham Horsham Rochester Winchester	Andover Hollingbourn Kingsclere and Whitchurch Maidstone Malling
uth-west ngland nd South Vales, II, VIII Wales 1)	Bath *Bristol* Cardiff Exeter Taunton	Bath *Bristol* Exeter	Barry *Gelligaer* Nantyglo and Blaina	Rhondda *Wellington*	—

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