with differing degrees of antigenic activity before a decision on this question is reached. Antigenicity tests in guinea-pigs (Gard *et al.*, 1956) and cotton-rats (Tobin, 1956) are also being investigated in parallel with the field studies.

Investigations are also to be made of the decline of antibody levels in some of the children who took part in the present study to obtain information concerning when a third booster dose should be given.

Summary

A study of the antibody response produced by the three batches of poliomyelitis vaccine used in Britain in the 1956 immunization programme was made in a group of 196 children who had no detectable poliomyelitis antibodies before their course of inoculations.

The children received two doses of vaccine at an interval of three to four weeks, and antibody response to the three types of poliomyelitis virus was determined two weeks after the second dose. No untoward reactions were observed in any of the children as a result of the inoculations.

All except two of the children produced antibodies to all three types, and the average response to each of the three batches of vaccine was similar.

The antigenic activities of the three batches were also shown to be similar when tested in monkeys and of the same order as that of an American vaccine.

The committee is grateful to the parents who consented to have their children vaccinated, and also thanks the Ministry of Health for the supply of poliomyelitis vaccine.

REFERENCES

- Enders, J. F., Weller, T. H., and Robbins, F. C. (1952). *Fed. Proc.*, **11**, 467.
 Gard, S., Wesslén, T., Fagracus, A., Svedmyr, A., and Olin, G. (1956). *Arch. ges. Virusforsch.*, **6**, 401.
 Gear, J. (1956). *S. Afr. med. J.*, **30**, 587.
 Sabin, A. B. (1955). *Ann. N.Y. Acad. Sci.*, **61**, 1050.
 Salk, J. E. (1956). *Amer. J. publ. Hlth.*, **46**, 1.
 Tobin, J. O'H. (1956). *Brit. J. exp. Path.*, **37**, 161.
 United States National Institutes of Health (1955). "Minimum Requirements for Poliomyelitis Vaccine."
 von Magnus, H., von Magnus, P., Petersen, I., Godtfredsen, A., and Rønkaer, M. (1955). *Dan. med. Bull.*, **2**, 226.

POLIOMYELITIS STUDIES IN AN ISOLATED SCOTTISH COMMUNITY

BY

A. D. MACRAE, M.D., Dip.Bact.

Virus Reference Laboratory, Colindale, London, N.W.9

During recent years it has been established that poliomyelitis, spread through human association, is widely disseminated throughout the world. Overcrowding and a low standard of living are associated with the early development of immunity which, once established, appears to persist throughout life. Reinfection may occur to bolster up immunity, but Paul *et al.* (1951), from investigation of an isolated Arctic community lacking opportunities for frequent reinfection, have shown that poliomyelitis antibodies may persist in the blood for many years. The development of these antibodies could be temporally aligned with well-separated outbreaks of the disease in the area.

The natural development of immunity to poliomyelitis is less evident in countries and communities with a higher living standard, and many persons of all ages remain fully or partly susceptible to the disease. The introduction of such persons into an area in which the local population has to a large extent been naturally immu-

nized may result in outbreaks of poliomyelitis involving the new arrivals only. Hammon (1949) has reported this occurrence among recently arrived American children and adults in the Pacific island of Guam. From laboratory studies he found that most native children became infected and developed an immunity below the age of 1, confirming that poliomyelitis was widespread, though mainly inapparent, throughout the island. The circulating viruses showed an apparently increased degree of virulence in the presence of a more susceptible population. He commented on the opportunities for studying the behaviour of poliomyelitis presented by such isolated populations.

Poliomyelitis has been a notifiable disease in this country since 1912, but before 1947 no countrywide epidemics had occurred. In a number of areas there have been no reported cases over prolonged periods, owing either to the existence of a widespread immunity or to lack of exposure to virus. Studies of such a community in the Western Highlands of Scotland in which there had been no evidence of poliomyelitis for many years were planned in 1950. It was hoped by the collection of samples of blood and faeces from members of a representative number of households to determine whether poliomyelitis viruses were currently circulating or had been present in the past.*

Selection of Area

Among the points considered in the selection of a community were the following: (1) the relative remoteness from neighbouring villages and restricted means of approach; (2) the relative compactness of the community itself; too much scatter would add to the problems of collection of specimens; (3) the size and age range of the population; around 400-500 with a reasonable proportion

Map of Torrion area

of young people was thought most suitable; (4) the co-operation of the people in supplying information and suitable specimens, and the co-operation of the local medical services; (5) the past incidence of poliomyelitis in the area; (6) any local industries; and (7) the means of transporting specimens to the investigating laboratory.

The area finally selected lay on the north shore of Upper Loch Torrion on the west coast of Ross-shire (see Map). It included the population of Annat, Torrion, Fassag, Corrie, Alligin, and Diabaig. Poliomyelitis had not been diagnosed there within living memory. Approach was by a single road from Kinlochewe, a distance of about 12 miles (19 km.), with the nearest railway station a further 10 miles (16 km.) away at Achnasheen on the route from Dingwall to Kyle of Lochalsh. The local occupations consisted of estate work, crofting, forestry, and fishing. There were few facilities for visitors. Children attended schools in the area up to the age of 11.

*The investigation was planned and the collection of material was organized by Drs. F. O. MacCallum, I. N. Sutherland, and W. C. Cockburn.

The houses in the area were identified on ordnance survey maps and numbered. Lists of the occupants of each house, with details of occupation, age, and school attended if a child, were prepared. In all there were 104 houses with a total population of 294, who had an age range as shown in Table I. Families with one or more children lived in 28 of the houses.

TABLE I.—Age Range of Torridon Population

Years:	0-5	6-10	11-15	16-30	31-50	51-91	Total
Males	13	8	12	21	40	52	146
Females	11	6	6	18	40	67	148
Total	24	14	18	39	80	119	294

Selection of Donors

It was hoped to obtain specimens of blood and faeces from one child in each of the 28 houses, from the youngest child where there were more than one, or failing that from the next youngest, and so on. In addition blood was to be obtained from 30 persons, aged 15 and over, and selected by random sampling from the houses with no children. Specimens of faeces were to be obtained from 12 of these persons. All specimens were to be sent, as quickly as possible after they were obtained by the doctor and nurse, to the nearest bacteriological laboratory. This was 70 miles (112 km.) away, at Inverness. There the serum was to be separated from blood clot and the faeces were to be frozen. The specimens, packed in dry ice, were then to be sent by passenger train to the Virus Reference Laboratory, Colindale.

Collection of Material

An approach, through the doctor and the district nurse, to the persons from whom material for investigation was desired, met with a good response. Specimens of faeces and serum were collected in the spring of 1951, between mid-March and mid-May, and again from the same persons, except for a small number who could not be contacted or who were unwilling, between mid-October and mid-December of the same year. The specimens came from 64 adults and children living in 53 of the 104 houses. There were children under 16 years of age in 25 of the houses. The distribution of the material is shown in Table II. That

TABLE II.—Distribution of the Material

Types of Specimen	Age Range in Years						Total
	0-5	6-10	11-15	16-30	31-50	51-91	
Paired sera and stools	4	5	5	2	2	7	25
„ stools only ..	7	—	—	—	—	—	7
„ sera only ..	2	1	—	1	10	9	23
Other combinations	4	1	1	—	—	3	9
Total ..	17 (12)	7 (7)	6 (6)	3 (3)	12 (9)	19 (16)	64 (53)

Figures in parentheses indicate the number of houses from which the specimens came.

samples of serum were not obtained from all children providing faeces was due to difficulty in obtaining blood from some of those under 5 years old. This difficulty had been foreseen, and when it occurred an attempt was made, where possible, to obtain samples of blood from the sibling nearest in age.

Further samples of blood were obtained in the late autumn of 1954 from 19 of the original donors. Of these, four were children up to 5 years old, six were children aged 6 to 10, and three were aged 11 to 15 years; two were adults aged 16 to 30, and four were aged 31 to 50 years. The intention then had been to bleed (1) those less than 20 years old in 1951, and (2) those over 20 years old with either no antibody in their serum against any type of poliomyelitis virus or with antibody to one type only. Early in 1956, samples of blood were obtained from the boy (Table III, No. 6) whose faeces yielded the two strains of poliomyelitis virus in 1951, and from his sister. This family had left Torridon for another locality.

Virus Investigations

The investigations consisted (1) in attempted virus isolation from the samples of faeces and (2) in determining whether poliomyelitis antibodies were present in the serum. The material, collected in 1951, was transported to the laboratory and stored there, frozen at -10°C ., until 1954, when it was examined.

Faeces.—A 20% suspension of each sample of faeces in buffered saline solution was centrifuged at 5,000 r.p.m. for at least one hour at 4°C . The supernatant fluid was harvested and tested for the presence of bacteria, being ready for virus investigation when bacteriologically sterile. Twenty-four pools, each composed of equal volumes of three suspensions, were prepared; those, and the remaining single suspension, were investigated in tissue culture and in newborn mice. When a virus was detected in a pool the suspensions composing it were individually studied.

Tissue Culture.—Epithelial cells of rhesus monkey kidney grown from minced tissue fragments or from trypsinized cell suspensions were used in the virus isolation and neutralization tests. Lactalbumin hydrolysate medium (Melnick and Riordan, 1952) or synthetic medium 199 (Morgan *et al.*, 1950) supplemented during the initial period of cell growth with 5% normal horse serum was employed. Tubes were incubated in stationary racks at 37°C . For isolation 0.1-ml. amounts of each pool were inoculated into five tubes, which were then observed microscopically at intervals for cell degeneration. The fluids were harvested when this became apparent or after 10–12 days in its absence. Three tissue culture passes were done before a pool of suspension was regarded as negative. Neutralization tests were based on the method of Ledinko *et al.* (1952), using 100 tissue-culture doses (TCD_{50}) of each virus type against increasing dilutions of serum and leaving each serum-virus mixture at room temperature (about 22°C .) for at least one hour before inoculation into tissue cultures. The virus strains used were Mahoney (type 1), Y-SK (type 2), and Saukett (type 3). The second samples of serum were tested at a single initial dilution of 1 in 2.5 against the three types of poliomyelitis virus and against the newly isolated Coxsackie B3 strain of virus. Where antibody was present against a type of poliomyelitis virus both samples of serum were titrated in increasing half-log dilutions against that virus. In the antibody titrations of the samples of serum obtained in 1954 and 1956 increasing twofold dilutions were used. The serum dilutions given in the tables are the final dilutions after the addition of virus suspension.

Animal Inoculation.—Litters of mice less than 24 hours old were inoculated subcutaneously with 0.02-ml. amounts of each pool suspension or with individual positive suspensions and tissue-culture fluids. Second mouse passages were done when there was evidence of weakness, tremors, or paralysis in the initial passage. Two rhesus monkeys were inoculated intracerebrally (0.5 ml.) and intramuscularly (2 ml. combined with an equal volume of adjuvant —“arlacel A,” “bayol F”) with tissue-culture fluids of No. 4 or No. 6 strains (Table III). Three rhesus monkeys, each inoculated intracerebrally (0.3 ml.) with faecal suspension from No. 6, were used in the identification of the newly isolated strains of virus from this child.

Results of Virus Isolation

Seven cytopathogenic agents were isolated on first passage in tissue culture from six samples of faeces from young children (Table III). In each instance the faeces was an autumn sample, the earlier specimens from the same children obtained in the spring being negative, as were the other 67 specimens. Five agents were identified as being strains of Coxsackie virus group B, type 3, by neutralization tests using specific antiserum obtained from Dr. Dalldorf. The cell degeneration produced by these strains occurred in a varying proportion of the culture tubes inoculated with each faecal suspension and characteristically

TABLE III.—*Virus Isolations*

No.	Age in Years	House No.	No. in Household	Faeces Sample	Cell Degeneration in 1st T.C. Passage*	Day of Appearance of Degeneration	Virus Identity
1	9/12	54	8†	Autumn, 1951	1/5	5th	Coxsackie B3
2	28/12	53	4	"	1/5	4th	"
3	8/12	55	3†	"	4/5	3rd	"
4‡	5	75	4	"	1/5	5th	"
5	8/12	31	6	"	2/5	10th	"
6	11/12	48	3	"	5/5	3rd	Poliomyelitis type 2 and type 3

* Number of tubes showing degeneration over number of tubes inoculated.
 † All the other persons in these households had Bornholm disease.

‡ Paired sera were available from this child; no serum was obtained in 1951 from the others.

developed slowly in the first passage. In the later passages the degeneration appeared more rapidly and was more complete.

In mice inoculated with pooled faecal suspensions, only one pool which contained the strains of virus No. 1 and No. 2 gave rise to signs of infection. In this instance, weakness, tremors, and varying degrees of paralysis developed after seven days in a litter of six, three of which ultimately recovered, surviving beyond a three-weeks period. In a second passage, using a 20% mouse carcass suspension, the effect was similar, with six mice dying and four recovering. When the five individual faecal suspensions containing Coxsackie virus were inoculated into litters of mice the same slowly developing signs of infection were noted in four instances, but inoculation of further litters with positive tissue-culture fluids yielded more rapid and clear-cut results.

The remaining two agents, isolated from the sixth sample of faeces, were identified as being strains of poliomyelitis virus, type 2 and type 3 respectively. The possibility of this occurrence arose when it was found that serum from the monkey inoculated with tissue-culture fluid of No. 6 strain neutralized types 2 and 3 poliomyelitis virus. The separation of the two strains in monkeys and in tissue culture had already been reported (Macrae and Shepherd, 1955).

Results of Serum Neutralization Tests

The distribution of antibody against the poliomyelitis viruses in the various age groups, based on the serum samples collected in the autumn of 1951, is shown in Table IV. Up to the age of 10, four out of 15 children possessed

TABLE IV.—*Distribution of Neutralizing Antibody to Poliomyelitis Viruses in Serum* of Persons in Different Age Groups in 1951*

Age Range in Years	No. of Persons	Antibody Against Poliomyelitis Virus						
		Type 1	Type 2	Type 3	No. Anti-body	No. of Types		
						1	2	3
0-5	8 (24)	0	1	0	7	1	0	0
6-10	7 (14)	1	2	0	4	3	0	0
11-15	6 (18)	4	3	1	2	1	2	1
16-30	3 (39)	1	1	1	2	0	0	1
31-50	12 (80)	3	8	4	2	5	5	0
51-91	19 (119)	16	14	16	0	0	11	8
Total	55 (294)	25	29	22	17	10	18	10

* Tested at a final dilution of 1/5.

Figures in parentheses are the total population in each age group.

antibody, in each instance against one virus type. From the age of 11 onwards, a gradual development of antibody, particularly against virus types 1 and 2, was apparent, although the small number of serum samples from the 16-30 year group does not allow a clear picture of events in this age range to be drawn. After the age of 30 exposure to the three types of virus appeared to have been about equal.

Titration of the paired samples of serum obtained in 1951 were done (1) to determine the individual levels of antibody and (2) to see whether any development of im-

munity against poliomyelitis virus had occurred during the summer. The results of titration, representing the second samples of serum, are shown in Table V; with one excep-

TABLE V.—*Neutralizing Antibody Levels in the Torridon Sera in 1951*

Poliomyelitis Virus	Range of Serum Dilutions						Total
	< 5	— 32	— 100	— 320	— 1,000	> 1,000	
Type 1	30	10	9	2	3	1	55
" 2	26	7	8	9	4	1	55
" 3	33	14	5	2	0	1	55

tion (Table VI, No. 2) the titres of the earlier samples of serum showed only minor differences within the limits of experimental error. Of the 19 samples of serum obtained in 1954, 10 were without antibody against any type of poliomyelitis virus; 7 of these were from children who had been less than 10, and one came from a child who had been 15 years old in 1951. The other two sera were from adults who had been 24 and 28 years old.

The remaining nine samples of serum and the two obtained early in 1956 were titrated, together with their preceding 1951 samples, and the results are given in Table VI. These show: (1) that the boy from whom the strains

TABLE VI.—*Persistence of Neutralizing Antibody to Poliomyelitis Viruses After an Interval of Three or More Years*

No.	Age (in 1951)	Sex	House No.	Serum and Year	Antibody Titres to Virus		
					Type 1	Type 2	Type 3
1*	1 1/12	M	48	1956	< 4	64§	32
2†	5	F	48	1951 A	< 4	< 4	< 4
				1951 B	< 4	64	< 4
				1956	< 4	32	16
3	8	F	77	1951 A	—	1,024	—
				1951 B	< 5	1,024	< 5
				1954	< 2	256	< 2
4	9	F	73	1951 A	—	180	—
				1951 B	< 5	150	< 5
				1954	< 2	512	< 2
5	10	M	41	1951 A‡	32	< 5	< 5
				1954	32	< 2	< 2
6	11	M	47	1951 A	—	< 5	—
				1951 B	< 5	< 5	< 5
				1954	< 2	256	< 2
7	12	F	33	1951 A	256	—	—
				1951 B	512	< 5	< 5
				1954	256	< 2	< 2
8	33	M	18	1951 A	—	54	—
				1951 B	< 5	46	< 5
				1954	< 2	54	< 2
9	36	F	57	1951 A	—	128	—
				1951 B	< 5	90	< 5
				1954	< 2	56	< 2
10	38	M	57	1951 A	—	430	—
				1951 B	< 5	256	< 5
				1954	< 2	256	< 2
11	46	F	2	1951 A	2	—	4
				1951 B	2	< 5	4
				1954	2	< 2	4

* Types 2 and 3 poliomyelitis virus were isolated from this boy in 1951. No sample of serum was obtained then.

† Sister of No. 1.

‡ No sample of serum obtained in autumn, 1951.

§ Reciprocal of serum dilution: calculated by Kaerber's method.

of poliomyelitis virus types 2 and 3 were isolated in 1951 had antibody to these types in 1956; (2) that the sister of this boy had developed antibody to type 2 virus before the collection of her second 1951 sample of serum and had also developed antibody to type 3 virus at a later time; (3) that a boy (No. 5) living in a house close to the home of these children developed antibody to type 2 virus between 1951 and 1954; (4) that a girl (No. 3) with a high antibody level against type 2 virus in 1951 showed a four-fold drop in titre by 1954; and (5) that the other antibody levels showed little variation during the three-year period.

The tests with the samples of serum obtained in the autumn of 1951 showed that 12 contained antibody against the Cocksackie group B type 3 virus. These came from six children less than 10 years old and from six adults ranging in age from 26 to 62. These children, including one (Table III, No. 4) from whom a strain of virus was isolated, and one adult had developed the antibody in the interval between the taking of the first and second specimens, the earlier sera being negative. In three adults the antibody was already present in the spring samples of serum, and in the remaining two adults only the autumn samples of serum were available for testing. The children came from scattered houses throughout the community, but, except for one of pre-school age, attended the same school. A strain of Cocksackie B3 virus had also been isolated from the brother (Table III, No. 1) of one of the children.

In tests with the samples of serum obtained in 1954, 10 persons were found with antibody against the Cocksackie B3 virus. Of these, one was a child (Table III, No. 3) from whom a strain of virus had been isolated in 1951, but from whom no serum had previously been obtained; three were children already positive in 1951; and six were from persons, previously negative, with ages ranging from 9 to 38 years and living in houses scattered throughout the community.

Discussion

Torrifon, in which no recorded cases of poliomyelitis have occurred, is a sparsely populated and relatively isolated area. It may, however, be reached from London within 24 hours, without difficulty at most times. As in other Highland communities the population is decreasing, owing to the drift away to the towns in search of work and greater amenities. After the age of 11 the children go elsewhere to complete their education; the young adults stay away because of the lack of work, but some return to settle down in late adult life.

The distribution of antibody to the poliomyelitis viruses appears to bear some relation to this. Up to the age of 11 years, 15 of the 38 children available were investigated serologically; 11 of these had no antibody to any type of virus, and four had antibody against a single type. The three children with type 2 antibody were aged 5, 8, and 9 years, the youngest having developed this during the summer of 1951. One child aged 10 had antibody to type 1 virus. In the 11-15 year group, six of the 18 children available were investigated serologically; four had antibody to type 1 virus, one of these having antibody to all three types, one to type 2 virus, and one to type 3 virus also. As the purpose of the investigation was to sample separate households, the extent of infection in siblings was not estimated. It would appear, however, that infection with type 2 virus had occurred in a number of households during the previous ten years and infection with type 1 virus before that, but there had been no widespread distribution of these viruses.

In the 16-30 year group samples of serum from only three persons were obtained. As one person had antibody to all three types of virus and two were completely negative it is not possible to reach any conclusions. After the age of 30 an increasing proportion of persons had antibody to one or more types of virus, probably acquired elsewhere in a number of instances. The antibody distribution in children differs from that found in Bettws-y-Coed, North Wales (Fallon, 1956), an area from which no cases of poliomyelitis had been notified since 1912. There, antibody against the poliomyelitis viruses, particularly types 1 and 2, was found in the sera of children from the age of 1 onwards, and only 6 out of 57 sera from children under 10 were devoid of antibody.

Although the isolation of two strains of poliomyelitis virus from a boy in the autumn of 1951 showed that these viruses were present in the area, there were no notified cases of poliomyelitis in Torrifon during 1951 or subsequently. One adult at Kinlochewe, 12 miles (19 km.) away, was transferred to hospital as a suspected case of non-

paralytic poliomyelitis, but no virus was isolated from a sample of faeces obtained while she was in hospital. Serological evidence of recent infection in Torrifon was limited to the boy, his sister, and one child from a near-by house who was infected with type 2 virus only. This boy, his sister, and mother had returned to this country from the tropics before the start of the Torrifon investigation. No evidence of poliomyelitis infection was found in the material collected in the spring. Whether they had all gone away from Torrifon during the summer or whether there had been close contact with relatives or visitors from elsewhere during this time is not known. The age of the children makes it improbable that they had many contacts in the community, hence the limited spread of infection. In addition, there is the possibility, suggested by Dalldorf (1952), of interference with the spread of poliomyelitis virus by Cocksackie B viruses.

Outbreaks of Bornholm disease in 1951, in some instances associated with Cocksackie B3 virus, were reported from Scotland and England (Swain and Mitchell, 1953; Disney *et al.*, 1953). The disease was prevalent in Ross-shire during the summer and autumn, starting on the east coast and spreading westwards. From the Torrifon area 13 cases were reported to the medical officer of health (personal communication), including four who were donors of specimens in this investigation. Except for one donor whose serum contained no demonstrable antibody against the Cocksackie B3 virus in either 1951 or 1954, the cases occurred in houses in which evidence of infection with this virus was obtained either by isolation or by antibody development. The laboratory findings support the probability that the clinical illness in Torrifon was associated with this type of virus.

The five strains of Cocksackie virus isolated came from young children, three being from near-by houses and two from well-separated houses. One of these was also a combined post-office and shop, the child's father being post-master, shopkeeper, and, in addition, ferryman and warden of the local youth hostel. The serological findings confirm that infection was widespread, and the combined results are a contrast to the picture with the poliomyelitis viruses. They also serve as a model of what might happen with poliomyelitis, given suitable conditions.

Summary

An investigation of the semi-isolated community of Torrifon, in the Highlands of Scotland, for evidence of infection with poliomyelitis is reported. No clinical cases of poliomyelitis have ever been reported from there.

Out of a population of 294 living in 104 houses, samples of faeces, serum, or both were obtained in the spring and again in the autumn of 1951 from 64 persons living in 53 of the houses. Emphasis was placed on obtaining specimens from the youngest child in each family selected. Further samples of serum were obtained in 1954 from 19 of the original donors.

Strains of Cocksackie B3 virus were obtained from five young children living in separate houses, and strains of poliomyelitis virus types 2 and 3 were isolated from one young boy in another house.

The development of antibody against types 2 and 3 poliomyelitis virus during these studies occurred only in the sister of the boy from whom the viruses were isolated, although serum from the boy himself, obtained five years after the virus isolations, did also contain these antibodies. One other child from a near-by house to these children developed antibody against type 2 virus only.

The distribution of antibody in the serum of donors indicated that immunity to poliomyelitis developed

relatively late in life, but that antibody levels, where present, showed little variation over a three-year period.

Serological evidence of widespread recent infections in children and adults with Coxsackie B3 virus corroborated reports of Bornholm disease in the area.

I am indebted to Drs. F. O. MacCallum, I. N. Sutherland, and W. C. Cockburn for advice and encouragement; to Drs. R. D. Martin, D. MacRae (since deceased), J. Landess Horne, Josephine W. Shepherd, H. MacPherson, H. Williams, and the district nurse for their co-operation; and to Dr. G. Dalldorf for the Coxsackie B antiserum.

REFERENCES

- Dalldorf, G. (1952). *J. Mt Sinai Hosp.*, 19, 396.
 Disney, M. E., Howard, E. M., Wood, B. S. B., and Findlay, G. M. (1953). *British Medical Journal*, 1, 1351.
 Fallon, R. J. (1956). *Lancet*, 1, 65.
 Hammon, W. M. (1949). *Bact. Rev.*, 13, 135.
 Ledinko, N., Riordan, J. T., and Melnick, J. L. (1952). *Amer. J. Hyg.*, 55, 323.
 Macrae, A. D., and Shepherd, P. A. (1955). *Monthly Bull. Minist. Hlth (Lond.)*, 14, 55.
 Melnick, J. L., and Riordan, J. T. (1952). *Proc. Soc. exp. Biol. (N.Y.)*, 81, 208.
 Morgan, J. F., Morton, H. J., and Parker, R. C. (1950). *Ibid.*, 73, 1.
 Paul, J. R., Riordan, J. T., and Melnick, J. L. (1951). *Amer. J. Hyg.*, 54, 275.
 Swain, R. H. A., and Mitchell, R. G. (1953). *British Medical Journal*, 1, 1354.

DEATHS FROM POLIOMYELITIS AMONG BRITISH DOCTORS

BY

RICHARD DOLL, M.D., M.R.C.P.

*Member of the Statistical Research Unit of the
Medical Research Council*

AND

A. BRADFORD HILL, C.B.E., F.R.S.

*Professor of Medical Statistics, London School of Hygiene
and Tropical Medicine; Honorary Director of the
Statistical Research Unit of the Medical
Research Council*

In our study of lung cancer and other causes of death in British doctors in relation to their smoking habits we have observed 34,494 medically qualified men over nearly five years—that is, from November, 1951, to September, 1956, a total of a little more than 165,000 years of exposure.* Over this time and in these 34,494 medical men there have been recorded eight deaths from poliomyelitis (including one certified as acute polioencephalitis). In relation to the size of the population at risk eight is a very small number. Yet it is greatly in excess of the number that would be expected to occur if doctors were dying of poliomyelitis at the same rate as adult males in the general population of Great Britain. Applying to our population of medical men these general population rates in the ten quinquennial groups from age 20 to age 70 (no deaths occurred in the general population over the age of 70) gives an expectation of only 0.83 deaths. It may be that persons in the higher social classes are rather more at risk of contracting poliomyelitis than those in the lower social classes. That would be in accordance with some modern beliefs—though we know of no statistical evidence in this country in its support. But even making them three times as vulnerable we would not expect more than two or three deaths to put against the eight observed. It therefore seems that doctors are specially at risk either of contracting poliomyelitis or, having contracted it, of dying from it.

*In our previous report (Doll and Hill, 1956), the total number of years of exposure observed was referred to as 148,686, but at that time data were available for deaths occurring only until March, 1956.

All those who died were relatively young men. At time of death their ages (last birthday) were 28, 30, 30, 32, 36, 37, 39, and 41. In their work there was no evidence of special risk—for example, in a laboratory. Their last known appointments were hospital casualty officer, hospital medical officer, chest physician, orthopaedic hospital officer, and general practitioner (4). These appointments were widely scattered—London (2), Middlesex, Berkshire, Kent, Staffordshire, Yorkshire, and Lincolnshire. In time, on the other hand, the deaths were curiously concentrated, since five of them occurred in August and September, 1952. The poliomyelitis season in this country is such that one would expect deaths to be specially concentrated in those months, but in each of the 1953 and 1956 seasons there was but one death of a doctor from poliomyelitis and in 1954 and 1955 there was none. The eighth death occurred at the end of the 1951 season (January, 1952). On the other hand, the total number of adult male deaths from poliomyelitis in Great Britain in 1952 (98) was the same as in 1953, not very different from the number in 1955 (105), and only about double that in 1954 (46 deaths) and, it seems likely, 1956.

Summary

The evidence given here suggests that men between the ages of 25 and 45 who are practising medicine in Great Britain are at special risk of dying of poliomyelitis. The actual number of deaths recorded (8) is small in relation to the number of men at risk (nearly 35,000), but at the rates of the general population not more than one death would have been expected to occur.

REFERENCE

- Doll, R., and Hill, A. B. (1956). *British Medical Journal*, 2, 1071.

INVESTIGATION OF NON-ULCER DYSPEPSIA BY GASTRIC BIOPSY

BY

A. WYNN WILLIAMS, M.D., D.C.P. (Lond.)

Senior Lecturer in Pathology, University of Edinburgh

FELICITY EDWARDS, B.M., M.R.C.P.

Research Assistant, West Middlesex Hospital, Isleworth

T. H. C. LEWIS, B.M., B.Ch.

Medical Registrar, West Middlesex Hospital, Isleworth

AND

N. F. COGHILL, M.A., M.B., M.R.C.P.

Physician, West Middlesex Hospital, Isleworth

Large numbers of patients with dyspepsia come to hospital, and often, in spite of appropriate investigations, no cause for it can be found. Although symptoms may abate when a patient learns of negative findings they often persist, and treatment may be difficult and unsatisfactory. A nervous cause of the indigestion may be suspected, but it is difficult to prove. In fact, dyspepsia of unknown aetiology constitutes a notable clinical problem.

Gastritis has long been suggested as a cause of non-ulcer dyspepsia, but in common with others we have found its diagnosis by gastroscopy far from certain (Wirts *et al.*, 1951; Shallenberger *et al.*, 1951; Palmer, 1952; Debray *et al.*, 1953; Selesnick and Kinsella, 1953). The suction biopsy tube introduced by Wood *et al.* (1949) offered a new means of obtaining information