EPIDEMIOLOGY OF THE 1947 OUTBREAK OF POLIOMYELITIS IN ECCLES*

BY

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Eccles covers an area of about 3,500 acres; its southern boundary is formed by the Manchester Ship Canal. Irlam Urban District lies to the west; Worsley and Swinton Urban Districts to the north, and Salford County Borough to the east. One-half of the borough consists of reclaimed peat land, unsuitable for building. The other half, in which all but one of the cases occurred, is completely "built up."

This portion of the borough is bisected from north to south by the Bridgewater Canal and is quartered by the intersection of two main arterial roads. The estimated population in June, 1947, was 41,940, living in 12,717 structurally separate dwellings. Practically the whole of the population falls into the Registrar-General's three lower social grades. The infant mortality rate in 1947 was 45.5. The borough is a typical Lancashire working-class urban district.

The method of field study followed broadly the usual pattern of inquiry into cases of infectious disease, being rather more extensive and detailed than usual. A visit was made to the household immediately on notification; and details of dates of onset, list of members of the household, giving ages, occupation, and places of work, and particulars of any recent illnesses, were recorded on a standard form. Any known direct or indirect contact was noted, also visits and visitors. Details and sources of foodstuffs, especially milk, ice-cream, and fruit, were noted, together with usual inquiries about numbers of rooms, sanitary arrangements, and the presence of domestic animals, flies, and vermin. Further information received from outside sources usually necessitated other visits to a household; it was often found that useful additional information could be obtained at these later visits, when people had had an opportunity to think about the questions previously asked.

In all, 58 cases and 200 contacts were investigated in this manner: 46 cases and 180 contacts in Eccles and 12 cases and 20 contacts in the neighbouring district of Irlam—these latter in connexion with the origin of the outbreak in Eccles.

General Epidemiological Findings

Between July 4 and Nov. 1, 46 notifications were received. The first case occurred on June 18, the date of onset of the last was Oct. 25. A graph of the weekly incidence of cases shows a slow rise in the third week in June, a more pronounced rise in the middle weeks of July, a peak, explosive in type, in the week of July 27 to Aug. 2, followed by an initial rapid decline and a slower tapering off. At first sight the explosive type of curve suggests a disease of short incubation period and high infectivity in a susceptible population—an impression that is not substantiated on closer examination of the epidemiological findings.

The attack rate and age distribution are shown in Table I. It will be seen that the brunt of the infection fell upon pre-school children (61% of total). There was only one case in a child under 1. The eldest of the series was a man aged 26. The attack rate, 1.09 per 1,000, is very high—the highest to occur in any local government district during this epidemic. There were three fatal cases, giving a case

mortality of 6.5%. The sex incidence was 63% male, 37% female. In considering these figures it must be emphasized that the overall number of cases is small.

Graph showing weekly incidence of cases.

TABLE I.—Attack Rate and Age Distribution

	Age Groups in Years				
	0-4	5-9	10-14	15-	Total
No. of cases	28	11	3	4	46
Percentage	61	25	7	7	100
Attack rate per 1,000 ..	8.07	3.85	1.14	0.12	1.09

Incubation Period

Estimations of the incubation period have varied widely; the figures given in textbooks range from six to twelve days. It was found difficult to estimate an incubation period. To do this accurately it was thought necessary to establish a single exposure of limited duration. In only one instance was there a direct case-to-case contact; again, there was only one instance of two cases in one household, these two cases occurring within two days of each other and both probably infected from a common source. These limitations, combined with the fact that the outbreak occurred in an open populous community, largely accounts for this difficulty. In five of the early cases the criteria of a single exposure of limited duration were satisfied.

Case 1.—It was established that this patient, the first case in Eccles, had been visited by a cousin from Irlam. The visiting child lived in a part of Irlam where a small group of cases had occurred. The visiting child herself developed a sore throat, general malaise, and a temperature for 24 hours, and the following day visited the Eccles child. These two children were on affectionate terms, and kissed each other. Nine days after this visit the Eccles child developed poliomyelitis.

Case 2.—This child, aged 4, lived in an area up to then free from infection, and had only once been away from the immediate neighbourhood of its home for over a month. It was then taken to visit a grandmother in an area where three cases had already occurred. During this visit the child was nursed by the sister of a previous case who herself developed an abortive attack next day. The child developed poliomyelitis nine days after the visit.

Case 3.—This is the only example of a case-to-case contact. A girl and a boy, aged 11 and 12 respectively, both stamp-collectors, exchanged stamps, during which the usual licking of stamp hinges took place. The boy became ill the same evening and the girl 13 days later. For most of these 13 days the girl had been away in Anglesey on holiday and no other contact could be established.

Case 4.—The patient, an adult male, played cards with the father of two children who had previously contracted poliomyelitis within two days of one another. The cards used were old and the players licked their fingers. The man became ill exactly a week later. An interesting feature of this case was that the man had a short febrile illness for the 48 hours following the card game; this "illness of infection" is known to occur within

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one or two days of exposure (McFarlan, Dick, and Seddon, 1946). He recovered completely, returned to his work as a manual labourer, and became ill again with typical symptoms of onset five days later—that is, seven days after contact.

Case 5.—This patient, a child of 15 months, the second case to occur on the eastern side of the borough, had been away on holiday on a farm in North Wales and returned on July 18. It became ill on July 27 and must have become infected during these nine days. The family consisted of the child and mother only. On the day after the return from holiday, July 19, the child was taken to the western side of the borough to visit relatives living within a few doors of a previous case and contacts of that case, and became ill eight days later.

These five instances give incubation periods of 7 days, 8 days, two of 9 days, and 13 days.

Course of the Outbreak

Notifications in Irlam were maximal during the weeks of June 7 to 21; in Eccles in the week ending Aug. 2; in Salford, immediately to the east, during the week ending

was ill at home the mother did not leave the house and the father was working overtime on the west side of the borough; these circumstances probably account for the lack of an early spread from this focus. The case marked with a hollow cross was a fatal case that was never notified, but one from which it was possible to assess an incubation period (Case 1).

Map 2 shows the distribution of the 14 cases which began during the week of maximum incidence, July 27 to Aug. 2. These are widely scattered throughout the borough.

Map 3 shows the distribution of the 18 cases which occurred between Aug. 3 and Oct. 25, the date of onset of the last case. These cases tend to lie on the eastward side of the borough.

Map 4 is a composite map showing the distribution of all cases throughout the whole period. There is a tendency for cases to lie in close proximity to the main roads. Over one-half lie either on or within 50 yards of a main road, and three-quarters within 100 yards of a main road. There is some suggestion of grouping of cases. A closer examination of dates of onset reveals some centrifugal spread in two or three areas.

The whole of this area, only a mile and a half square, is densely populated. The outbreak was confined to the

MAP 1.—Distribution of Cases with onset June 18 to July 26.
= Main roads. ++++ Canals.

MAP 3.—Cases with onset Aug. 3 to Oct. 25.

MAP 2.—Cases with onset July 27 to Aug. 2.

MAP 4.—Showing distribution of the whole series of cases.

Aug. 9; and in Manchester, further east again, during the week ending Aug. 30. There seems to have been a marked spread from west to east as is shown in Maps 1, 2, and 3.

Map 1 shows the distribution of the 13 cases which started during the six weeks up to July 26. All these, except one, are on the westward side of the Bridgewater Canal. The exception was a case in which it was possible to assess an incubation period (Case 2). The family consisted of one child (the patient) and the mother and father. During the week when the child

western half of the area for nearly six weeks, and it seems that the Bridgewater Canal may have formed a barrier. This may seem to be far-fetched, but on closer examination it can be seen that communication between the two portions of the borough is restricted to three bridges, of which the lower one is rarely used by pedestrians. Each portion of the borough tends to have its own employment and amusement facilities and its own shopping centres.

Mode of Spread (Human)

Contacts

A history of direct or indirect contact with a previous case within a fortnight of onset was obtained in 20% of cases. If one adds visits of the patient or a member of the household from an area previously free from infection to an immediate locality where cases had already occurred the proportion is raised to 33%. The addition of instances where contact had almost certainly occurred, although not admitted, raises this proportion to 46%.

It was very striking how often during the first half of the outbreak indirect contact between cases could be established and, in contrast, how very rarely during the latter half.

During the same periods direct contacts alone had increased from about 50 to over 200; indirect contacts increased by a far bigger proportion, and were very widely scattered throughout the whole borough. Opportunities for indirect contact must have been very numerous during the latter half of the outbreak and correspondingly difficult to establish with certainty. Indeed, with opportunities for contact so great it is difficult to explain the escape of so many children. This proportion of indirect contacts suggests a carrier wave preceding the actual cases of paralysis.

The Abortive (Non-paralytic) Cases

An increasing interest has been taken in these cases in recent years. They are known to excrete the virus from the nasopharynx (Paul and Trask, 1932) and in the stool (Horstmann *et al.*, 1944, 1946). During the Eccles outbreak any short non-specific illness characterized by malaise, sore throat, headache, with or without backache or neck stiffness and not progressing to paralysis, was regarded as an abortive illness. There appeared to be no advantage, in an epidemiological investigation, in adopting the further clinical subdivision of such illnesses into abortive and non-paralytic forms. These symptoms could normally be indicative of many common respiratory infections but for the important fact that they occurred during an epidemic of poliomyelitis and also during a hot dry summer when respiratory infections would be least expected.

The data concerning abortive cases are unsatisfactory since they are largely based on a history of illness in contacts occurring at about the same time as the illness of the frank case. There were, however, 15 such instances of abortive poliomyelitis. This figure is almost certainly too low. Five of these cases were probably responsible for infecting persons who developed frank paralytic attacks of poliomyelitis.

In an attempt to assess more accurately the prevalence of abortive cases a survey of two areas of the borough during the outbreak was made (Table II). In these two

TABLE II.—Prevalence of Abortive Cases in the Immediate Neighbourhood of a Frank Case

Area	No. of Houses	Population		Frank Cases		Abortive Cases	
		0-15	Over 15	0-15	Over 15	0-15	Over 15
A	50	51	110	1	0	15	1
B	50	41	93	0	0	3	2

areas the housing conditions and social status of the inhabitants were comparable. Each area contained a small communal children's playground. In Area "A" a frank case of poliomyelitis had occurred. In Area "B" no cases had been notified. A house-to-house census of 50 houses in each area was undertaken and careful inquiries made of any illnesses during the months of July, August, September, and October. Two visits to each household, one at the

beginning of the outbreak and another at the end, were made. Each householder was asked to keep a careful record of all minor illnesses, and all school absentees living in these two areas were investigated. Area "A," in which the frank case occurred, contained 110 adults and 51 children under 15. In this area one adult and 15 children gave histories of illnesses compatible with a diagnosis of abortive poliomyelitis. These 16 cases occurred in two distinct foci—12 in adjacent households surrounding the house in which the frank case occurred, and four at the other end of this area but also in adjacent houses. Area "B" contained 93 adults and 41 children under 15. In this area two adults and three children gave histories suggestive of abortive illnesses (Table II). These five cases were widely dispersed throughout this area.

The high proportion of abortive to frank cases is borne out by inquiries made of general practitioners in the borough, several of whom estimated that in their private practices they saw between 10 and 20 abortive cases to one frank case.

Carriers

Carriers are known to excrete the virus for the same period as frank cases (Rhodes, 1947). The Eccles outbreak started with four cases practically simultaneously. The first (Case 1) was infected by a cousin from Irlam (an abortive case). The other three were probably infected by healthy carriers, household contacts of these cases being workmates of direct contacts of Irlam cases. Several later cases (including Cases 4 and 5) were also probably infected by healthy carriers.

Mode of Spread (Non-human)

The restriction of infection to the westward side of a canal less than 25 feet wide for 38 days, the geographical distribution of cases, together with other convincing epidemiological evidence, indicated that water, milk, other foods, rodents, domestic animals, flies, and railways played no significant part in the spread of infection.

Discussion

Age Distribution.—The corrected notifications for England and Wales for 1947 show that only 31% of cases occurred in the 0-4 age group (Registrar-General, 1947) compared with 61% in Eccles. Judging by the findings of observers in other countries the factors which probably account for the lower age distribution in Eccles are (1) the early onset of the epidemic (the last case occurred on Oct. 25, at which time cases were still being notified in England and Wales at the rate of over 250 a week); and (2) the high population density. The inhabited portion of the borough has a density of over 30 persons per acre.

Mode of Spread.—Factors which strongly indicated that, in Eccles, human contact played the major part in the spread of infection were: (1) evidence of carrier-to-case contact and contact between abortive and frank cases; (2) evidence of numerous abortive cases, especially in close proximity to frank cases; (3) a marked tendency for cases to lie on or in the immediate neighbourhood of main roads; (4) some suggestion of grouping of cases and centrifugal spread; (5) an initial marked restriction of the spread of infection by the Bridgewater Canal, where communications between the two halves of the borough are restricted; (6) a rapid spread once that barrier was crossed; (7) the exclusion of other important means of spread.

Sources of Infection.—The virus has been recovered from the pharynx of patients (Howe *et al.*, 1944) and contacts (Flexner *et al.*, 1913), from the faeces of cases (Pearson and Rendtorff, 1945) and contacts (Pearson *et al.*, 1945). Space does not permit a discussion of the

relative importance of these two sources of the virus. In the few instances during this outbreak where there was evidence of the prolonged or intimate personal contact, usually associated with faeces-spread diseases, the circumstances strongly suggested a nasopharyngeal spread of infection. Five of such instances are described in connexion with the incubation period.

Preventive Measures

The experience in Eccles was that schools played no significant part in the spread of infection. Two-thirds of the total cases and one-half of the cases among school-children occurred during the time the schools were closed for the summer holidays. No infection could be traced to school contact.

Notification should include abortive or non-paralytic cases. It has already been noted that these cases are many times more prevalent than the frank paralytic cases, are known to be infectious, are rarely recognized as such, and play a major part in the spread of infection—certainly a much more important part than the frank paralytic case in hospital.

It would be an advantage if the present regulation requiring the separate notification of polio-encephalitis and poliomyelitis was superseded by one reverting to the more accurate and comprehensive term of polio-encephalomyelitis, with perhaps a further subdivision into paralytic and non-paralytic or abortive cases. This would encourage more frequent and earlier notification and greatly assist the medical officer of health or those responsible for control and prevention.

As over two-thirds of the cases in England and Wales occurred in persons over the age of 5 the term "infantile paralysis" must now be regarded as a misnomer.

The isolation period usually recommended is three weeks (Memo. to Ministry of Health, 1947). In view of the findings of Horstmann *et al.* (1944, 1946) that 50% of patients are still excreting the virus in the stools between the third and the fourth week, this period is theoretically too short. The collected findings of Brown *et al.* (1948) that 20% of family contacts excrete the virus would indicate that isolation measures should, ideally, include the whole family.

Viewing in retrospect the wide distribution of cases (Map 4) and the high attack rate (Table I) one cannot help feeling critical of the efficacy of the accepted preventive measures. It must be realized, however, that although these measures are not likely to stop an epidemic they will certainly slow down its spread. Since epidemics nearly always abate with the onset of cold weather; this "slowing down" may be expected to result in a large number of susceptible persons remaining untouched who would otherwise become permanent cripples.

Summary

During the 1947 poliomyelitis epidemic the borough of Eccles suffered the highest attack rate of any local authority district. There were 46 cases, giving an attack rate of 1.09 per 1,000 of the population. The case mortality was 6.5%.

The incubation period was 7 to 13 days. Only one family had more than one frank case. There was only one instance of a frank case-to-case contact.

The epidemic was confined for nearly six weeks to the western half of the borough by a canal which restricted communications between the two halves.

The results of field studies indicated that the chief factor in the spread of infection was human contact, in which abortive cases and healthy carriers played the major part. The presence of the virus in the nasopharynx of patients and carriers was of much more importance for the spread of infection than was its presence in faeces.

A survey undertaken revealed the presence of numerous abortive cases, especially in close proximity to frank cases, and suggested that of every 20 persons who showed clinical signs and symptoms of infection less than one developed into a frank paralytic case.

Suggestions to improve the present system of notification are made, particularly the necessity for notifying abortive cases.

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THE OEKOLOGY OF POLIOMYELITIS IN A MILITARY CAMP IN 1947

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The widely held view that cases of overt poliomyelitis are to be regarded as the severer examples of a carrier epidemic makes the recognition of early non-paralytic cases of special importance (Memo. by M.O.s to Ministry of Health, 1947).

This paper is concerned with the search for such a carrier epidemic at Catterick Camp, where paralytic cases occurred during the 1947 epidemic. The population at risk can be broadly classified as follows: 13,500 to 14,500 young soldiers under training living in huts each containing 20 beds, and 3,540 inhabitants of 1,169 Army quarters—1,785 adults, 1,612 children under 15, and 143 children over 15.

Towards the end of June a case of poliomyelitis in the pre-paralytic state was isolated in the Military Hospital, and two other patients who did not develop paralysis were similarly treated because of meningism. After receiving information about another paralytic case in a near-by camp instructions were issued to admit all suspicious cases to hospital. This procedure resulted in the admission of eight paralytic cases, including a fatal one, ten probably abortive cases, and eight suspects. The paralytic cases included five young soldiers and one child from the camp area; four of these became ill between Aug. 2 and 26, one in June, and one in October.

Symptomatology of Paralytic Cases

An acute onset with headache, stiffness and pain in the back, occasional vomiting, and twitching of the muscle groups which later became paralysed was the rule. However, five of the eight paralytic cases had been slightly indisposed for about a week; only one had sought advice, and he had felt well enough to go on leave hitch-hiking the day before he was finally taken ill (Table I).

Objectively the early cases presented with pyrexia ranging from 101 to 102° F. (38.3 to 38.9° C.), slight drowsiness,