STREPTOCOCCAL INFECTIONS AMONG CHILDREN IN A RESIDENTIAL HOME

I. INTRODUCTION AND DEFINITIONS: THE INCIDENCE OF INFECTION

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(With 2 Figures in the Text)

Despite the general decline that has taken place in the severity of streptococcal infection, outbreaks of sore throat and scarlet fever are still not uncommon in schools and day nurseries and still present problems in management. The investigations reported in this paper were made in a large residential home for children, where one of our collaborators (C.V.B.) was at the time medical officer in charge. The study was conducted over the $2\frac{1}{2}$ years, November 1950 to April 1953, and then in less detail until April 1954.

MATERIAL

The situation

'The Village Homes', Barkingside, where our investigations were made, is one of the largest units of Dr Barnardo's Homes, and was founded by Dr Barnardo in 1873. It consists of sixty-one houses (fifty-five of which were occupied by children at some time or another during our survey) grouped around three large lawns. In addition, on the 65 acres of the site, there are a 100-bedded hospital, a school and two nursery schools, a church, and various administrative buildings (Fig. 1).

Most of the houses, or 'cottages', accommodate twelve children, but three take up to twenty-four; as a rule three to five children sleep in one bedroom. Each cottage has a dining room and playroom and all meals are taken in the cottage—in this as in many other ways the children of a cottage living like a large but otherwise normal family.

During our study two cottages were reserved for children of 18 months or less. Some of the other cottages were for pre-school children (aged about 18 months to

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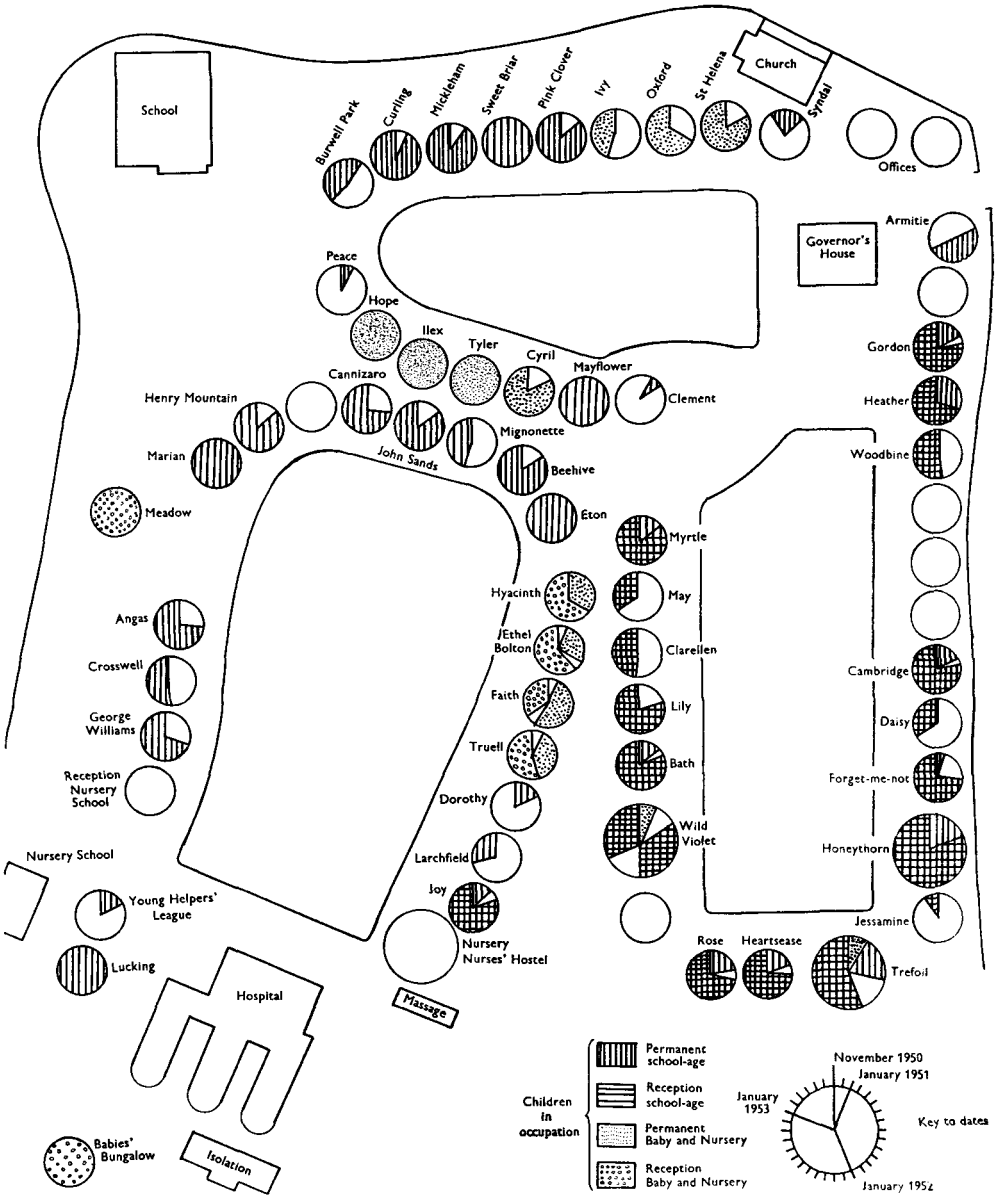

Fig. 1. Diagrammatic sketch map of the Village Homes, Barkingside. Scale approximately 1 in. = 30 yards. The shading of the areas in the circles represents the group of children in occupation over the indicated period. The cottages depicted with the larger circles are those with twenty to twenty-four children.

5 years)—often referred to as *nursery* cottages—and some were for the school-age children (5–15 years).

The *infant* and *nursery* cottages were each staffed by a resident matron assisted by a variable number of student nursery-nurses. The matrons stayed in one particular cottage for long periods, but the nurses, who were mostly girls aged 16–22 years, were moved from one cottage to another fairly frequently; most slept

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in a separate communal building. The *school-age* cottages were staffed either by a resident matron and a helper or by a married matron and her husband.

The children aged from 3 to about 5 years attended a nursery school (or later one of two nursery schools) in the grounds and, with the exception of three or four children of staff, none from outside the 'Village' was admitted.

Until September 1951 the children aged 5–11 attended the school in the grounds of the Village; children from outside also attended this school, but in a different department, with which there was little mixing. After September 1951 some of the 5–11 year children attended, as did older children throughout the study, various schools in the vicinity.

During a large part of our studies the Barkingside Village was one of the main reception units for children newly admitted to Barnardo's Homes. These children might remain in the Village for a few weeks or even months before being sent to a Branch Home or to foster parents; or they might remain at Barkingside indefinitely, but in this case they were transferred from *reception* to *permanent* cottages. We thus had a division of the child population into a *reception* group, who were expected to be transient visitors, and the *permanent* group—many of whom were resident there throughout the 30 months of our survey. The babies in the two cottages for children under 18 months are regarded as part of the *reception* group.

During the summer months, and in school holidays and week-ends, children from different cottages played together on the lawns, but even so the large open area and the layout of the Village resulted in considerable segregation. Since the *reception* and *permanent* cottages were situated in different regions of the Village (Fig. 1) the children from these two groups of cottages did not mix much; there was probably even less mixing among nursery-age children than among school-age.

On admission to the Village all the children were examined in the hospital. Subsequently, they attended the hospital out-patient department for the diagnosis and treatment of all illnesses and injuries, even minor cuts and bruises. Any child who had a fever, or was sick enough to need to go to bed was admitted to the hospital wards. It was thus fair to assume that virtually all febrile illnesses of more than one day's duration appeared in the hospital records. The only exceptions to this rule were, first, that during the extensive epidemics of influenza such as occurred in two of the three winters of our study, the hospital had not always sufficient beds; and, second, that a number of children with mild acute otitis, or with an exacerbation of chronic otitis, were treated by daily injections of penicillin without admission to hospital.

The hospital served not only the Barkingside Village but also the nearby Woodford Barnardo homes which, during a great part of our study, had a child population similar to Barkingside; in addition, children from other Barnardo homes in various parts of the country came to Barkingside for tonsillectomy and sometimes for other hospital treatment. Staff from the Barkingside and Woodford homes were also admitted to the hospital.

The investigations

The backbone of our studies was the bacteriological investigation of all children admitted to the hospital with a febrile upper respiratory tract infection and symptoms or signs of an inflamed throat, or with acute otitis. When two or more children from one cottage had sore throats or otitis due to the same type of streptococcus within about 2 weeks we visited the cottage and swabbed the healthy and convalescent children and staff. Apart from cottage outbreaks of infection, we investigated healthy children only during one 6-month period of the investigation, considering that such routine swabbing would, judged from the incidence of sore throats in previous years, be largely wasted.

The records

For each month of our survey, it was known which individual children were in each cottage and group of cottages (*nursery* and *school-age*; *reception* and *permanent*) or were in hospital. We could, therefore, specify the population exposed to risk of sore throat, etc., classified by age, sex, and, since we were particularly interested in the influence of tonsillectomy on susceptibility to streptococcal infection, by 'tonsil state'. For information on tonsil state we relied on the observations recorded at the time of a child's admission to the Village, supplemented by records of tonsillectomies carried out, and on clinical observations during illnesses.

With few exceptions, we also knew the school and class attended by each child of school age, and whether younger children attended the nursery school. We could specify the class-mates of all (before September 1951) or the majority (after September 1951) of children aged 5–11. For older children, at all times, we knew the school attended, but since the schools were outside the Village, we could not know all their class-mates.

The analyses

In this paper we have analysed the incidence of streptococcal infections on the total Village population or its subdivisions, and given some account of the bacteriology of the illnesses observed. In subsequent papers (Holmes & Williams, 1958*a*, *b*) we shall study the infected contacts to whom particular children were exposed and from whom they may have become infected, and the influence of (i) previous experience of streptococcal infection, and (ii) tonsil state on the results of the exposure. We shall then turn from infection in the individual child to the outbreaks of infection in cottages and in the Village as a whole, analysing first the source of the cottage or Village introduction, and secondly the factors influencing spread (Holmes & Williams 1958*c*).

DEFINITIONS

Populations

For the analyses of attack rates based on the whole child population of the Village (part I), a child was regarded as present for any month of which he spent 16 or more days in the cottages; children in hospital or on holiday were excluded, as were the few children of members of the staff.

For analyses other than those in part I, all children, including those of the staff, who were present in the cottages at the material time were included. In some analyses members of the cottage staff were also included. We have not studied illnesses that developed in children while in hospital.

Age. For calculating attack rates by ages, all children born in, for example, 1949 were assumed to be aged 4 years for the whole of 1953. For grouping purposes we have used either the groups: less than 1; 1 and 2; 3 and 4; 5 and 6; 7–11; and over 11 years, which correspond to the usual divisions of nursery school and school, or the natural divisions of the home: '*baby*' (up to about 18 months), '*nursery*' (from about 18 months to 4 years), or '*school*' (5 years and over). In the latter case all children living in, for example, *school-age* cottages were assumed to be of 'school age' although, rarely, one or two rather younger children were present in these cottages.

Tonsil state. A child's tonsils were regarded as 'out' if they had once been removed, even if remnants were still present. The tonsils were regarded as 'in' if no operation or, in rare instances, a simple adenoidectomy, had been performed.

Clinical diagnoses

All the clinical diagnoses were made by C.V.B., or by one of the deputy medical officers, Dr N. Lowe and Dr O. N. Bywaters, and they were recorded on the hospital notes (from which they were abstracted) before the results of laboratory examinations were received; the clinical diagnoses did not, therefore, rely on the bacteriological report.

Sore throat. The term 'acute sore throat' is used for upper respiratory tract illnesses in which the major signs or symptoms were referable to the throat. Most were diagnosed as 'tonsillitis' or 'pharyngitis'. For convenience we have included in this group the few diagnoses of 'stomatitis' when made on children less than 1 year old, and those of 'laryngitis' (only three of which were observed).

A 'streptococcal sore throat' is an acute sore throat which yielded Group A haemolytic streptococci from throat swabs taken on admission to hospital or, in a very few cases, during the 3 days before admission to hospital.

When streptococci of different serological types were isolated from nose and throat, that from the throat was regarded as the infecting type.

It is appreciated that our definition allows children, who were carrying the streptococcus but suffering from a non-streptococcal sore throat, to be wrongly classified, but it was not feasible to collect blood for serological or haematological tests so that no alternative basis of diagnosis seemed open. In fact 90 % of all the children diagnosed as suffering from streptococcal sore throat had moderate or large numbers of streptococci in throat cultures and 53 % also had streptococci in the nose; 81 % of a random sample had fever of 100° F. and 54 % had fever of 102 °F. or more at some time; and at least 54 % had exudate on the tonsils in the acute stage. We considered that the proportion of false diagnoses was probably not very large.

We have tried to discover whether we failed to recognize any substantial proportion of the streptococcal throat infections by comparing the cottage incidence of 'non-streptococcal sore throats' during the periods of outbreaks of recognized

streptococcal sore throats with that observed at other times. In the *school-age* cottages there was no evidence, and in *nursery* and *baby* cottages only a slight indication, that 'non-streptococcal' sore throats were commoner during the time of 'streptococcal' outbreaks, so we concluded that our bacteriological diagnostic methods were adequate.

The normal treatment for children with sore throat was sulphamezathine (sulphadimidine, B.P.), 2 g. daily for 5 days.

Otitis. This term is used for all attacks of otitis that required systemic chemotherapy; it does not include cases of external otitis without inflammation of the drum or middle ear, nor mild exacerbations of chronic otorrhoea.

'Streptococcal otitis' means otitis with Group A streptococci in a swab from the ear or, more often, only from the nose or throat. This diagnosis is not precise, partly because the association of otitis with a streptococcal throat carrier state is not necessarily causal, and partly because 40 % of the children with otitis did not have even nose or throat swabs taken.

Other respiratory infections. This term included the clinical diagnoses of coryza, croup, tracheo-laryngitis, bronchitis, influenza or 'flu, pneumonia, pneumonitis, bronchiectasis, pleurisy, pulmonary tuberculosis, whooping cough, and unspecified respiratory tract infections. A small number of these infections were associated, epidemiologically or bacteriologically, with streptococcal infection; they are included as such in the analyses for source of infection, etc. (parts II, III and IV) but not in the analyses of attack rates (part I).

The term 'total respiratory infections' includes sore throat, otitis, and other respiratory infections.

Gastro-intestinal infections. These include diarrhoea, with or without vomiting, Sonne dysentery, gastric 'flu, etc. Babies admitted on account of 'feeding trouble' are not included in our tables.

No case of acute rheumatic fever or of acute nephritis was seen during the survey.

BACTERIOLOGICAL METHODS

Swabs were taken from the nose and throat of practically all patients who, on admission to hospital, had sore or inflamed throats; from about two-thirds of patients with otitis; and from some of the patients with other respiratory infections. Nose and throat swabs were also taken from these patients on discharge from hospital and, from April 1951 to July 1952, on two occasions during convalescence, one about 7–10 and one between 14–28 days after discharge.

From May 1952 to December 1953 patients with acute sore throat also had swabs taken from the front of the mouth to detect streptococci in the saliva.

The external ear was swabbed when otorrhoea was present on admission, but not if the ear drum perforated in hospital.

At routine swabbings of cottages we took nose and throat swabs, and from April 1952, saliva swabs.

Swabs to be sent to the laboratory through the post were stabbed into agar to preserve the streptococci during transit (see Homes & Lermit, 1955).

Pike's (1944) enrichment method, or some modification of it (Holmes & Lermit, 1955), was used to detect small numbers of streptococci. All nose swabs, and all throat swabs taken on admission to hospital were plated directly as well as after enrichment; throat and saliva swabs from routine cottage swabbings were often plated only after enrichment.

The plating medium was horse-blood agar containing 1:1,000,000 crystal violet; it was incubated anaerobically overnight.

All colonies resembling haemolytic streptococci were subcultured and tested for group, either by Maxted's (1948) enzyme-grouping method, or by his (1953) bacitracin-screening method. The type of Group A streptococci was determined by Griffith's (1934) slide-agglutination method supplemented in many cases by the precipitin test of Swift, Wilson & Lancefield (1943). The latter was omitted on follow-up cultures, and on most of the strains agglutinated as *Types 2, 9,* or *22*.

Three provisional types of streptococci named after the cottage where they were first found were recognized by their peculiar agglutination patterns.

Type	Agglutinated characteristically by sera for types
'*Lily*'	*12* and *13*, and often *3*, *27* and *44*
'*Corby*'	*13*, *27* and *44*
'*Angas*'	*11*, *27* and *44* or *27/44*

Satisfactory precipitin sera for these types were not available.

RESULTS

The incidence of infections

Population at risk

When our investigation commenced in November 1950, about 300 children were living in the Village; by the close, in April 1953, the number had risen to about 500 (Table 1). Most of this increase took place in the summer of 1951 and was due to the opening of *reception* cottages, especially for *school-age* children.

Table 1. *Average number of children in the Village*

Ages years)	Nov. 1950 to Apr. 1951		May 1951 to Oct. 1951		Nov. 1951 to Apr. 1952		May 1952 to Oct. 1952		Nov. 1952 to Apr. 1953		Average		No. child-months exposure in 30 months' study	
	P	R	P	R	P	R	P	R	P	R	P	R*	P	R
<1	0	4	1	7	0	6	2	15	2	8	1	10	30	236
1–2	24	11	25	20	22	20	30	19	25	27	25	22	753	577
3–4	37	0	47	5	43	15	42	16	45	19	42	17	1273	327
5–6	63	1	54	22	50	31	49	29	50	30	53	30	1595	672
7–10	92	3	67	49	74	60	84	65	93	56	82	60	2456	1400
11–	76	1	68	33	67	52	70	48	74	51	71	50	2121	1108
ll ages	292	20	262	136	256	184	277	192	289	191	274	189	8228	4320

P = permanent group; R = reception group.

* This average is computed from November 1951 to April 1953, i.e. over 18 months, in which period there were 88 child-months of exposure.

Numbers of infections

During the 30 months, a total of 473 attacks of sore throat were observed among the children and 282 (59·6 %) of these were 'streptococcal' (Table 2). Only about 10 % of the sore throats were not swabbed so that, within the limits of our bacteriological methods, the proportion given as 'streptococcal' is probably accurate.

Table 2. *Number of respiratory tract illnesses observed during the survey*

	No. of illnesses			Percentage of patients yielding streptococci in throat (or ear) swabs		
Illness	Children	Staff	Total	Children	Staff	Total
Sore throat	473	95	568	59·6	59·0	59·5
Otitis	354	7	361	24·6*	(42·8)	24·9
Other respiratory infections	314	Not recorded	—	—	—	—

* Only 215 of the 354 children had nose, throat and, in cases of otorrhoea, ear swabs examined; 87 (40·5 %) of the 215 yielded streptococci from one or more sites.

Note. This and subsequent tables include the results from a few children not admitted to the hospital, as noted on p. 45.

There were 354 attacks of otitis, 24·6 % associated with streptococcal infection, but swabbing was omitted in the case of about 39 % so that this estimate of the proportion associated with streptococcal infection is unreliable. In the period October 1951 to September 1952, during which 80·8 % of the 146 cases of otitis were swabbed, the percentage associated with streptococci was 39·0 and over the whole study 40·5 % of the 215 patients swabbed yielded streptococci from the nose or throat (or ear).

There were 314 cases of 'other respiratory infection' which were rarely swabbed although certainly in some cases due to streptococci.

With the younger children, there is a further diagnostic difficulty, namely, that many (21 % of those aged up to 4 years) could be shown to be carrying the streptococcus more than 7 days before the onset of their illness. The etiological importance of the streptococcus is therefore in considerable doubt. This problem hardly arises with the older children.

Examination of a sample of the hospital out-patient records indicated that between 50 and 70 % of the children requiring any treatment for respiratory tract infections (including otitis) were admitted to the wards. The figures in our tables, which cover all of these together with some cases of otitis not admitted to the wards, therefore include at least this proportion of all respiratory illness requiring treatment.

The serotypes of the streptococci responsible for the infections are shown in Table 3. At the time when *Type 2* was prevalent we failed to obtain swabs from a substantial proportion of the children with otitis, so that *Type 2* otitis may have been more common than appears from this table.

Table 3. *Frequency of different serotypes of* Streptococcus pyogenes *isolated from children and staff with sore throats and otitis*

	Sore throats		Otitis		Total	
Type	No.	% of total	No.	% of total	No.	% of total
2	77	22·8	9	10·0	86	20·1
5	55	16·3	17	18·9	72	16·8
22	41	12·1	9	10·0	50	11·7
12	33	9·8	16	17·8	49	11·4
'*Lily*'	32	9·5	6	6·7	38	8·9
9	25	7·4	9	10·0	34	7·9
4	12	3·5	3	3·3	15	3·5
'*Corby*'	10	3·0	5	5·6	15	3·5
6	7	2·1	5	5·6	12	2·8
3	8	2·4	0	0	8	1·9
28	8	2·4	1	1·1	9	2·1
11	6	1·8	1	1·1	7	1·6
'*Angas*'	5	1·5	2	2·2	7	1·6
8/25	3	0·9	2	2·3	5	1·2
18	4	1·2	0	0	4	0·9
1	1	0·3	3	3·3	4	0·9
19	1	0·3	1	1·1	2	0·5
36	0	0	1	1·1	1	0·2
Untypable	7	2·1	0	0	7	1·6
Not tested	3	0·9	0	0	3	0·7
Total	338	100·3	90	100·1	428	99·8

Attack rates

In comparing the incidence of disease in the various subgroups of the population it is convenient to base the rates on the numbers of 'child-months at risk', and, because of the small number of *reception* children in the Village before July 1951 we have used only the period July 1951 to April 1953 in Table 4. Attack rates could not readily be calculated for the staff.

The attack rate for all diagnoses, and in almost all age-groups, was higher among *reception* than among *permanent* children (Table 4), but the excess was not great.

The incidence of streptococcal sore throat increased with age up to 5 to 6 years, after which it changed little; non-streptococcal sore throat varied irregularly with age but tended to decline among the older children. Consequently, of the illnesses diagnosed as 'sore throat' the proportion yielding streptococci increased from about 34 % in the 1–2-year-old group to about 74 % in the children over 10 years old. The proportion of the sore throats yielding streptococci was almost always higher among the *reception* than the *permanent* children, but we have no explanation of this.

Both otitis and the other respiratory infections had their highest incidence among the younger children and declined steeply in the older. On the figures available there was not much evidence that the proportion of cases of otitis associated with streptococci varied with age, but closer analysis showed that

Table 4. *Attack rates for various diseases per* 100 *child-months at risk, during the period July* 1951 *to April* 1953

	Age (years)													
	<1		1–2		3–4		5–6		7–10		10		All ages	
	P	R	P	R	P	R	P	R	P	R	P	R	P	R
Acute sore throat, streptococcal	0	0	0·5	1·7	1·4	3·7	1·9	3·4	1·9	2·5	2·0	3·4	1·3	2·5
Acute sore throat, not streptococcal, or not swabbed*	3·7	1·0	2·1	1·9	3·7	1·2	1·2	1·9	0·8	2·1	0·9	1·0	2·1	1·5
Percentage streptococcal sore throat/total sore throats	**0**	**0**	**20·0**	**47·1**	**27·1**	**75·0**	**61·8**	**64·7**	**70·2**	**54·1**	**69·8**	**78·3**	**41·5**	**53·2**
Otitis, streptococcal, not streptococcal, or not swabbed	18·5	4·9	6·0	5·1	3·7	4·9	3·4	6·4	1·9	2·2	1·4	2·0	2·8	3·5
Other respiratory infections	0	2·9	4·8	6·2	3·7	9·9	1·9	3·9	1·6	1·4	1·5	1·9	2·3	4·4
Total respiratory infections	**22·2**	**8·8**	**13·4**	**14·9**	**12·5**	**19·7**	**8·4**	**15·6**	**6·2**	**8·2**	**5·8**	**8·3**	**8·5**	**11·9**
Percentage streptococcal sore throat/total respiratory illnesses	**0**	**0**	**4·0**	**11·4**	**11·0**	**18·8**	**22·6**	**22·0**	**30·3**	**30·6**	**34·1**	**41·1**	**17·0**	**20·7**
Gastro-intestinal infections	0	2·4	4·8	5·8	1·7	6·2	1·0	1·1	0·3	0·5	0·2	0·7	1·0	1·8
Total number of child-months	27	206	566	469	959	325	1107	639	1753	1313	1520	1046	5932	3998

P = permanent group; R = reception group.

* 10·7 % of 364 sore throats were not swabbed.

streptococcal otorrhoea had a somewhat higher proportional incidence in the children aged under 5 years than in older children (Table 5).

The total incidence of hospital admission for respiratory tract infections declined from about 15 per 100 child-months for the children under 5 years, to about 7 for those aged 7 and over. 'Streptococcal sore throats' formed a relatively small proportion of the total respiratory infections in the younger children; in older children, however, they reached 30–40 % (Table 4, summarized in Table 5).

Table 5. *Sore throats and otitis, as percentage of all febrile respiratory tract illnesses, in three age groups*

	Children aged			
	Up to 3 years	3 and 4 years	5–15 years	All ages
Sore throat, streptococcal	8·6	16·0	32·0	24·7
Sore throat, not streptococcal	13·6	19·5	16·7	16·8
Otitis total	37·8	28·1	30·1	31·0
Otorrhoea, streptococcal	2·5	2·2	0·8	1·4
Other respiratory infections	40·0	36·4	21·2	27·5
Total cases	198	231	712	1141

N.B. This table is based on the whole period of study, whereas Table 4 is based on the period July 1951 to April 1953.

Though not shown in the table, attack rates for streptococcal sore throats were calculated separately for boys and girls; they were 2·4 and 2·1 per 100 child-months, respectively—a difference that is not statistically significant. There was no indication of a sex-difference in attack rates in the *reception* and *permanent* groups, nor at different ages.

Time trends

The attack rates for each of the 30 months of the study are shown in Fig. 2.

Apart from one striking outbreak in the autumn of 1951, the incidence of streptococcal sore throat was generally rather irregular. The number of sore throats on which the monthly rates are based varied between two and thirty so that some of the irregularity is due to random fluctuations; it is largely, however, due to the succession of small outbreaks that go to make up the general level of infection, as will be shown later (Holmes & Williams, 1958*c*).

Non-streptococcal sore throats, despite the smaller numbers, had a comparatively stable incidence from month to month. The one peak in the curve, in the summer of 1951, was at a time when we suspected some defects in our cultural methods and we may have failed to recognize some streptococcal infections; the incidence of streptococcal infections was rather low at the same time. Five of the eleven cases were in one cottage.

The fact that rather a large proportion of children with otitis escaped swabbing makes it difficult to assess the time trends for otitis; but there is no evidence in the figures of any seasonal variation in 'streptococcal otitis'. On the other hand, both

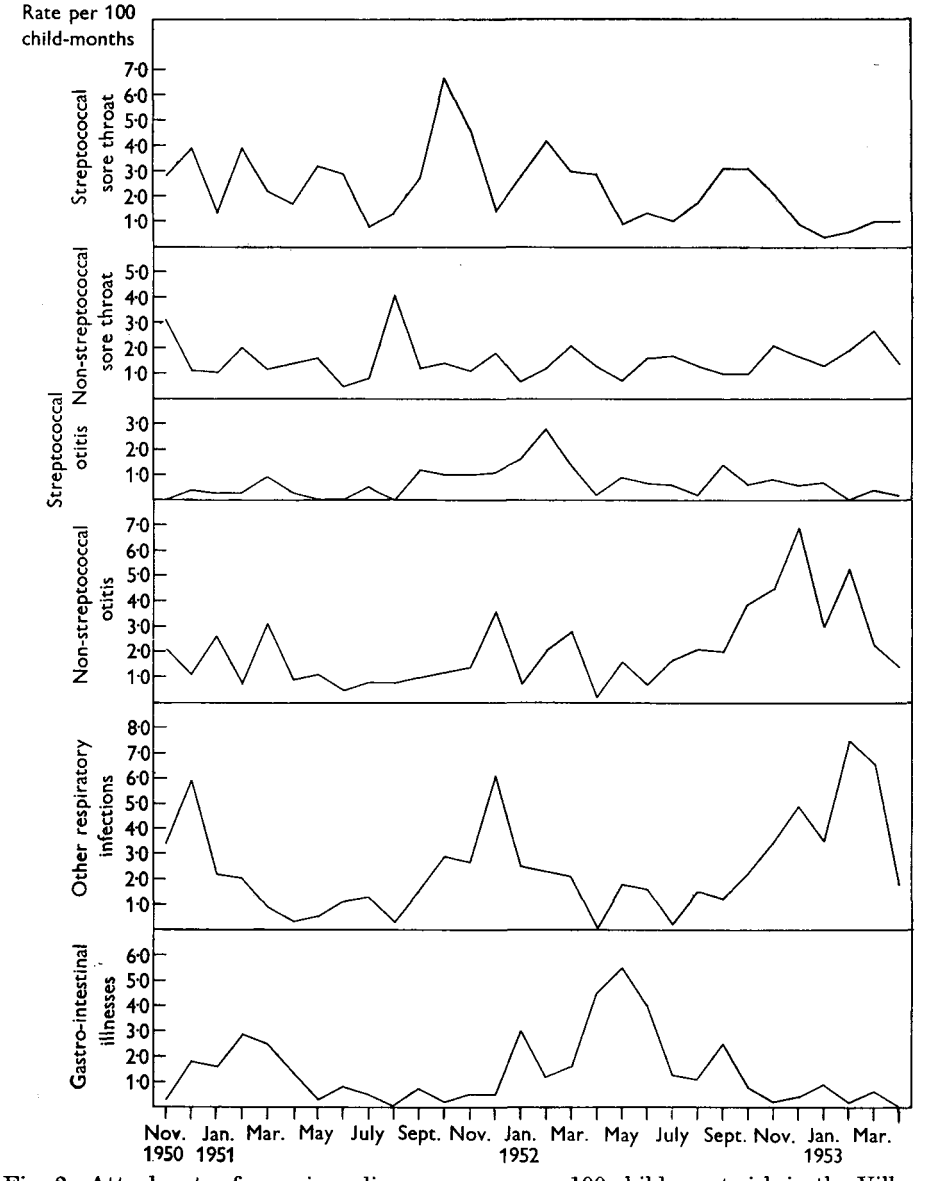

Fig. 2. Attack rates for various disease groups, per 100 children at risk in the Village.

non-streptococcal otitis and the 'other respiratory infections' had distinct and almost simultaneous winter peaks. Gastro-intestinal infections, which were recorded for comparison, had two peaks of incidence—in the winter of 1950–51 and in the summer of 1952. Both were outbreaks of Sonne dysentery.

Characteristics of the streptococcal sore throats

A more detailed study was made of the 114 children with streptococcal sore throat for whom a full series of admission, discharge and convalescent swabs was obtained (Table 6). About 14% of the sore throats were complicated with some

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other condition, either on admission, during their stay in hospital, or within 1 month after discharge; in 8 % the complication was otitis.

Complications developing after admission were seen more frequently among the tonsillectomized than the non-tonsillectomized children (18·8 % compared with 7·3 %), but in the absence of complications the illness seemed to be somewhat milder in the tonsillectomized group—as judged by duration of fever, and by the smaller proportion of cases for which it was considered necessary to replace the usual sulphamezathine treatment by penicillin.

Table 6. *Characteristics of streptococcal sore throats among school-age children*

	Children with tonsils		
	Present	Removed	Total
Number of sore throats	82	32	114
Percentage with maximum fever less than 100° F.	17	22	18
Percentage with maximum fever 100–102° F.	46	47	47
Percentage with maximum fever more than 102° F.	37	31	35
Mean duration of fever, days	3·1	2·0	2·8
Percentage with complication (otitis, etc.) on admission to hospital	3·7	3·1	3·5
Percentage developing complications due to original streptococcus while in hospital or after discharge	4·9	12·5	7·0
Percentage relapsing with original illness and original streptococcus	2·4	3·1	2·6†
Percentage with second attack of sore throat or with complication due to a newly acquired streptococcus*	2·4	6·3	3·5
Percentage acquiring a new streptococcus but developing no complication, etc.	18·3	9·4	15·8
Percentage of uncomplicated cases requiring no more than symptomatic treatment	4·1	18·2	7·4
Percentage of uncomplicated cases treated with sulphonamides	75·4	72·7	74·7
Percentage of uncomplicated cases treated with penicillin or penicillin and sulphonamide	20·5	9·1	17·9

* All but one occurred after the child's discharge from hospital.

† Two of the three children had had penicillin treatment in the acute stage.

Persistence of streptococcal carriage in convalescence

Streptococci were present in the nose of 45 % of the children with streptococcal sore throat on admission to hospital; the proportion was 71 % in the tonsillectomized as compared with 33 % in those retaining their tonsils. In convalescence, the tonsillectomized children seemed to lose their throat streptococci more rapidly than the non-tonsillectomized, but there was little difference in the rate at which they lost their nasal streptococci (Table 7, which is based on substantially the same group of children as Table 6).

At the time of admission to hospital 62 % of seventy-eight children with streptococcal sore throats had streptococci in their saliva swabs. Of twenty-nine children examined on discharge from hospital, twenty-six were carrying streptococci and 69 % of these (62 % of all the children) were salivary carriers. Forty-four children

Table 7. *Duration of streptococcal carrier state in school-age children convalescent from streptococcal sore throat*

	Tonsils present				Tonsils removed			
		Percentage				Percentage		
	No. of children	Nose and/or throat carriers	Nose carriers	Nose carriers, of total carriers	No. of children	Nose and/or throat carriers	Nose carriers	Nose carriers, of total carriers
On admission	92	100·0	32·6	32·6	42	100·0	71·4	71·4
On discharge from hospital	72	84·8	25·0	29·5	35	88·6	28·6	32·3
7–13 days after discharge	67	82·0	26·9	32·7	29	69·0	44·8	65·0
14–28 days after discharge	61	78·7	26·2	33·3	27	74·1	33·3	45·0
2–4 months after discharge	33	66·7	18·2	27·3	19	26·3	15·8	60·0
5–8 months after discharge	18	44·5	5·6	12·5	10	30·0	20·0	66·7
9–12 months after discharge	5	80·0	20·0	25·0	5	0	0	—

N.B. Children receiving penicillin treatment in hospital excluded from all except first row. Twenty children wl had less than a full set of convalescent swabs appear in this table but not in Table 6.

were examined later in convalescence; thirty-nine of them were carriers and 54 % of them (48 % of all the children) were salivary carriers. (In only four of a total of 818 examinations were streptococci found in saliva when the organism was not present in the throat swab.) There was some indication that, even allowing for differences in total carrier rates, the tonsillectomized children had streptococci in their saliva less often than children with tonsils.

There was a suggestion that the children with tonsils had a greater tendency than the tonsillectomized to continue to carry the original infecting type of streptococcus until they became infected with another type. There were eighty-eight children with tonsils who were examined sufficiently often in convalescence to show when they lost their original infecting type, and who were not treated with penicillin. In 40 % of these, the first swab found negative for the original type, yielded *Streptococcus pyogenes* of a different serotype; the corresponding percentage for the twenty-two tonsillectomized children was 27, but on these figures the difference is not statistically significant.

Bacteriology of excised tonsils

Many workers have found that it is often possible to cultivate streptococci from tonsillar tissue excised at operation when swabs rubbed over the surface of the tonsils before operation fail to yield any streptococci. We examined excised tonsils from 121 children who had been observed for at least 3 months before tonsillectomy and who were not given penicillin cover for the operation.

Sixty-eight (56·2 %) of the 121 excised tonsils examined yielded cultures of a single type of *Str. pyogenes* (ten colonies from each culture being the same type); 79·3 % of the erstwhile owners of the streptococcal tonsils had yielded the same type of streptococci from throat swabs taken the day before operation, and 87 % had yielded the same type within the previous 1 or 2 months. Only one of the

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children whose tonsils yielded no streptococci had had any on the admission swab; a larger proportion had been infected earlier.

Altogether forty of the 121 children had had a streptococcal infection of the upper respiratory tract within the preceding 3 months; twenty-two had not been treated with penicillin, and twenty-one of these had streptococci of the type that caused the infection still present in their tonsils. Only seven of the eighteen who had been treated with penicillin yielded streptococci from the tonsil, and in three of the seven they were of a different type from that causing the earlier infection. Fourteen children had had a non-streptococcal respiratory infection, and only two of them had streptococci in their tonsils.

DISCUSSION

This paper summarizes the 'vital statistics' of streptococcal infections among children resident in the Barkingside Village and forms a background to subsequent papers analysing the epidemiology of the infections.

In considering the results, it is perhaps worth, first, dispelling any idea that, because the children live in an orphanage, their general level of 'health' is likely to be low. Physical deprivation due to economic circumstances is now not often the reason for admission to Dr Barnardo's Homes; the need for care is more often related to personality or family difficulties. As some measure of nutritional status the heights and weights of a random sample of eighty children from the *permanent* group at Barkingside were compared with those recorded for children in London County Council schools for 1954 (Report, 1955). The Barkingside children were on the average 1·0 in. shorter, and 1·1 lb. lighter than the London County Council children. The children in the *reception* group at Barkingside were similarly slightly shorter and lighter than children of the same age in the *permanent* group, but the differences were even smaller than those just recorded. On the other hand, it is certainly true that, from the fact that the children live in 'families' of twelve to twenty the likelihood of infection being transferred among them is greater than it would be in normal families with one to three children.

Our statistics lose some precision from the fact that we were unable to attempt serological confirmation of our diagnosis of streptococcal infections, so that all febrile children with inflamed throats and streptococci in their throat cultures were regarded as suffering from streptococcal sore throats. We did not demand the presence of large numbers of streptococci, because small numbers may result from technical defects of collecting or examining the material rather than a real difference in the degree of infection; in fact some 90% yielded moderate or large numbers of organisms in their swabs. Our impression is that we have not included more than about 10% falsely diagnosed cases. There is no evidence that any large numbers of the streptococcal infections were missed.

Among the factors that initiated this study of streptococcal infections among the children living in the Barkingside Village was the general impression that such infections were unduly common. Over the 30 months of our investigation streptococcal throat infections had an incidence of about 1·9 per 100 children per month,

and constituted about 50 % of all cases diagnosed as sore throat, and some 20 % of all the respiratory tract illnesses leading to admission to the hospital—i.e. that were associated with one day or more of fever. Though strict comparison with the rates recorded for other child populations is impossible, such an incidence does not seem to be particularly unusual.

Thus, in a study of air disinfection among school-children at Southall (Report, 1954), absences from school attributed to pharyngitis and tonsillitis (including scarlet fever) had a rate of 2·3 per 100 child-months in the age range 5–11 years. Judged from our experience, about 50 % of these infections might be streptococcal, so that streptococcal infections might have had a rate of 1·2 per 100 child-months, and accounted for about 9 % of all the absences from school attributed to respiratory illness; but it is certain that many of these absences would not have been associated with fever, and would not therefore have led to admission to the Barkingside hospital.

In the residential schools studied by the Medical Research Council in 1930–39 (Report, 1938; Cheeseman, 1950) the incidence of sore throat lay between 1·3 and 3·0 per 100 children per month (assuming that all school terms were of 3 months' duration). The total incidence of disabling respiratory infection was 4·6–5·7 per 100 child-months in the boys' schools and 12·7 in the girls' schools (Table XIII of Cheeseman, 1950). These rates were for children aged 13–17 and in general the incidence of sore throats was lower than we observed in the over-10 children at Barkingside. We observed none of the sex difference reported from the public schools; but there is, at Barkingside, no difference between the sexes in the criteria for admission to hospital and this may support the conclusions of the Report (1938) that the sex difference observed in the public schools lay in differences in care and reporting rather than in differences in incidence.

Dingle, Badger, Feller, Hodges, Jordan & Rammelkamp (1953) and Badger, Dingle, Feller, Hodges, Jordan & Rammelkamp (1953) studied the incidence of respiratory disease in families living at home; their rate for all 'respiratory illnesses' was 6·2 per person per year, or 52 per 100 persons per month, with a variation from about 67 in the younger children to 40 in the adults. Over all ages, 2·4 % of all respiratory illnesses were streptococcal sore throats and 1·6 % non-streptococcal sore throats: these give rates of 1·2 and 0·8 per 100 person-months, respectively, which do not differ greatly from those we observed.

In the family studies in New York State reported by Coulter (1952) tonsillitis and related illnesses (including otitis) had incidence rates of about 0·9 to 1·1 per 100 person-months and formed 7 % of the total acute respiratory tract illness. These rates, like those of Badger *et al.* (1953) just quoted, refer to adults as well as children.

The incidence of otitis observed at Barkingside (1·4–3·9 per 100 child-months at various ages over 5) is somewhat higher than the rate of 1·0 per 100 child-months observed in the Southall study.

Even if streptococcal infections were no more common than elsewhere, they were, nevertheless, a substantial element in the sickness experience of the Barkingside children, and proportionally, streptococcal infections were much more important among the older children.

We observed no case of rheumatic fever during the 30 months' survey, although, if Rammelkamp, Wannamaker & Denny's (1952) estimate of 3 % as the incidence of this complication of streptococcal infection were accepted, we might have expected about eleven cases among the 367 cases of streptococcal illness recorded. Cases of inapparent carditis would not have been recognized, since no routine cardiological follow-up studies were made, but no case of manifest rheumatic fever could have been missed.

There were no cases of acute glomerulonephritis despite the fact that *Type 12* streptococci were responsible for forty-nine cases of infection. Only four of the children with streptococcal sore throats had scarlet fever rashes.

The influence of tonsillectomy on streptococcal infections was one of our principal interests throughout this study. Little difference was found in the severity of the infections, although there was a suggestion that tonsillectomized children with streptococcal sore throats had slightly milder illnesses than children who retained their tonsils. The lack of any great difference in severity confirms observations previously recorded in the literature (e.g. Rantz, Spink & Boisvert, 1947; Commission, 1945; Mertz, 1954).

A more striking difference is seen in the results of swabbing. On admission to hospital the tonsillectomized children were far more often nasal carriers than the non-tonsillectomized, and this difference persisted throughout convalescence, although the throat carrier rates tended to decrease more rapidly in the tonsillectomized children than in the non-tonsillectomized.

The influence of the tonsil state on streptococcal carrier rates has been studied frequently and some of the results are summarized in Table 8; all refer to throat carriage, and all show that the tonsillectomized children carry streptococci less often than the non-tonsillectomized. In a previous survey (Holmes & Williams, 1954) we confirmed these results and found the same difference for nasal carriage.

Table 8. *Throat carrier rates of* Streptococcus pyogenes *in children with and without tonsils*

Place	Age group (years)	No. tested	Percentage carrying *Str. pyogenes*		Reference
			Tonsils in	Tonsils out	
Melbourne	4–14	210	19	3	MacDonald, Simmons & Keogh (1940)
Dallas	0–15	900	28	14	Pike & Fashena (1946)
Dunedin	5–15	1023	9	5	Kirschner & Gallagher (1949)
Melbourne	7–12	530 (1275 swabs)	28·7	9·4	Holmes & Rubbo (1953)
London	5–15	1641	28·0	7·9	Holmes & Williams (1954)

The results of Table 7 can, in part at least, explain the differences observed in the previous surveys so far as throat infection is concerned: the higher carrier rates for children with tonsils could be due to their more prolonged carriage of the streptococci. They cannot explain our previous observation of a lower prevalence of nasal carriage in tonsillectomized children. To reconcile these results we should

have to assume that the tonsillectomized children acquired streptococcal infection less often than the non-tonsillectomized; we shall return to this point in a subsequent report (part III).

The children in the *reception* cottages experienced a higher attack rate for all sore throats than those in the *permanent* cottages, but the difference seemed to be greater for the streptococcal than for the non-streptococcal illnesses. This may reflect the acquisition of some immunity to streptococcal infections from stay in the village, while less immunity is acquired for other infections.

SUMMARY

1. In a children's home with an average population of about 460 children aged from 0 to 15 years, 473 attacks of acute sore throat, 354 attacks of otitis and 314 attacks of other acute febrile respiratory tract illness were recorded in the 30 months from November 1950 to April 1953.

2. The attack rate for all forms of illness and at all ages was higher among children in a *reception* group, who were mostly recently arrived in the home, than it was in the *permanent* residents.

3. Of all illnesses with the principal signs or symptoms referable to the throat, the proportion that yielded *Streptococcus pyogenes* rose from about 34 % in the 1–2-year-old children to about 74 % in the children aged 10 years or more. Streptococcal sore throats made up about 8 % and about 38 % of all febrile respiratory tract illnesses in the same two age groups.

4. The attack rate for streptococcal sore throat varied from month to month between 0·5 and 6·5 % of the children at risk; only one period of substantially increased prevalence was observed and there was no indication of any seasonal trend. Non-streptococcal sore throat varied between 1·0 and 2·0 % per month. It was not possible to recognize any epidemics of streptococcal otitis; non-streptococcal otitis had a definite winter prevalence associated with the rise in the total of non-streptococcal respiratory disease.

5. There was a slight indication that tonsillectomized children had rather milder attacks of sore throat than non-tonsillectomized under the routine sulphamezathine treatment adopted. About 86 % of all children still harboured the causative streptococcus in their throat on discharge from hospital. The tonsillectomized children lost their throat, but not their nose, streptococci in convalescence more rapidly that the non-tonsillectomized. Among throat carriers, the tonsillectomized children carried streptococci in their nose more often than the non-tonsillectomized at all stages in their illness and convalescence.

6. Bacteriological examination of excised tonsils did not often reveal the presence of streptococci that had been undetected in throat swabs. Twenty-one of twenty-two children who had had a streptococcal respiratory tract illness treated with sulphamezathine within the 3 months preceding their tonsillectomy were found to harbour the same streptococcus in their tonsillar tissue; only four of eighteen children whose illness had been treated with penicillin still harboured the streptococcus.

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