

CARRIERS AND RETURN CASES IN SCARLET FEVER

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INTRODUCTION

THE epidemiology and bacteriology of scarlet fever have been the subjects of extensive investigation and report during recent years. Increased impetus to enquiries was afforded by the identification of the haemolytic *Streptococcus* as the causal agent of the disease, and the subsequent preparation of streptococcal exotoxin and antitoxin led to further light being thrown on the problems of immunity and infection. In an enquiry into the epidemiological and administrative aspects of an infectious disease such as scarlet fever, where the causal agent is known and readily isolated by laboratory methods, the co-operation of the clinician and bacteriologist is essential. The results of such co-operation will indicate in how far the laboratory can be of help in the more efficient control of the disease. The elucidation of this point is one of the main objects of the present investigation.

One of the questions which have caused considerable controversy and which have even led to legal action is that of the "return case", and those responsible for the administration of a fever hospital have often been accused of inefficiency and negligence when a "return case" occurred. The term "return case" has been in use for a considerable time. Rolleston (1932) quotes an extract from a letter in the *British Medical Journal* as far back as 1893, and states that the term was in use prior to that date. In this country a "return case" is defined as "a case of infectious disease occurring in the same house within 28 days of a patient's discharge from a fever hospital". It should be noted that it states "a case of infectious disease", not necessarily a case of scarlet fever following a scarlet fever discharge, a case of diphtheria following a diphtheria discharge, etc. In the past and at the present time the opinion regarding freedom from infection of scarlet fever patients on discharge is based almost entirely on clinical examination. The opinion that a scarlet fever patient is free from infection, based upon duration of isolation, absence of complications, etc., is obviously open to question. The bacteriological examination of the nose and throat for the causative organism and the report of its absence fortify to a high degree the clinical opinion. Granted that in diphtheria the taking of swabs prior to discharge and the release from isolation on negative bacteriological findings do not seem to have affected the return case rate, yet negative swabs are a strong argument in favour of freedom from infection.

In 1898, under the late Metropolitan Asylums Board, Simpson (1899) carried out an investigation on the subject of return cases. In his report an alleged return case rate of 3.4 per cent. resulted from the discharge of 6507 cases of scarlet fever, but on analysis the true rate was shown to be 1.6 per cent. Of the infecting cases 80 per cent. were associated with rhinorrhoea, and one of Simpson's conclusions was that the warm bath on the morning of discharge was conducive to the occurrence of coryza and infectious rhinorrhoea.

In 1905 Cameron published the results of an extensive enquiry into the subject and found 688 return cases from 16,702 cases of scarlet fever discharged, a return case rate of 4.1 per cent.

In 1927, in a report to the Ministry of Health, Parsons agreed with the conclusions of Simpson and Cameron. The combined results of these investigations may be summarised as follows:

- (1) Morbid conditions of the nose, throat or ear were commonly present in the infecting cases; (the infectivity of otorrhoea was not conclusively established).

- (2) The proportion of infecting cases was probably less when the length of isolation in hospital was decreased, *i.e.* there was a positive correlation between the duration of hospital isolation and the percentage of return cases.

- (3) During epidemic periods when the standards of bed space and nursing efficiency were decreased, complications and cross-infections were more common and these led indirectly to an increase of infecting cases.

(4) The classification of cases on admission, segregation of septic cases, barrier nursing, and consulting otological services decreased the occurrence of infecting cases.

(5) The relationship between the number of return cases and overcrowding at home was not supported.

In all these reports the investigations were based solely on clinical findings. Gordon (1932) explored the question in Detroit and invoked the help of the bacteriological laboratory. His main conclusions were:

(1) The number of infecting cases was a more reliable index of the efficiency of isolation and discharge than the actual number of return cases.

(2) Infecting cases were more common among children, and bacteriological examination showed the carrier state to be more prolonged in children than in adults.

(3) The active factor in extending the period of infectivity of patients was the occurrence of complications during convalescence, and complications were more frequent in children.

(4) An infecting case rate of 2.4 per cent. in simple uncomplicated scarlet fever was increased to 6.0 per cent. when rhinitis, sinusitis, cervical adenitis or suppurative otitis media developed during convalescence.

(5) The frequency of infecting cases varied with the type of complication. The rate for patients with (a) multiple complications was 7.1 per cent., (b) rhinitis, 6.4 per cent., (c) cervical adenitis, 6.2 per cent. and (d) suppurative otitis media, 2.8 per cent.

(6) The infectivity of rhinitis depended on its character, varying from 14.7 per cent. in patients with active purulent discharge to 2.5 per cent. in those with serous nasal discharge (coryza).

More recently Hoyne and Bailey (1934) issued a report on return cases connected with patients discharged from the Municipal Contagious Disease Hospital, Chicago. Alterations in the criteria for the discharge of patients enabled them to study four groups under different regulations. In contrast to Gordon, they emphasised the importance of uncomplicated cases of scarlet fever becoming infecting cases and demonstrated that adults were by no means a negligible factor in the production of return cases. They also stated that the number of return cases bore an inverse ratio to the length of the isolation period, although this conclusion cannot be clearly deduced from their tables.

Gordon and Badger (1934) in Detroit reduced the period of isolation of scarlet fever patients to two weeks for adults and three weeks for children, and showed that this procedure had not resulted in an increase of the number of infecting cases. The convalescence of patients following return home was apparently quite satisfactory. They advocated early notification and hospitalisation with as short a period of isolation as was consistent with the clinical condition of the patient and the safety of susceptible individuals at home. They estimated that the cost of 9000 patient days had been saved during the year 1933 by the application of the foregoing regulations.

SCOPE OF INVESTIGATION AND TECHNIQUE

In the Ministry of Health report (1927) already referred to, the enquiries were carried out at a time when work on the bacteriology of scarlet fever was still in its infancy and the problem of the return case was approached mainly from a clinical standpoint. Since 1927 a considerable literature has grown round the relationship of the *Streptococcus pyogenes* to scarlet fever. The work of Griffith (1926, 1927, 1935), Glover and Griffith (1931) and Allison and Gunn (1932), in which the isolation and serological typing of *Streptococcus pyogenes* were applied to the protean manifestations of infection of the throat by haemolytic streptococci, encouraged the writers to investigate whether the laboratory could throw any further light on the factors governing the occurrence of return cases in scarlet fever. It was also considered of interest to ascertain to what extent the swabbing of convalescent patients would be of help from an administrative point of view, and, at the same time, to enquire whether there were any indications for shortening the period of isolation in scarlet fever.

The investigation was commenced at the beginning of 1933, when swabs were taken from each nostril and from the throat of all patients, convalescent from scarlet fever, immediately prior to discharge. The criterion for discharge was the clinical condition, and the bacteriological findings were not taken into account. The swabs were received in the laboratory within a few hours of being taken and cultures were made on plates of nutrient agar containing 5 per cent. of fresh oxalated horse blood. The plates were incubated at 37° C. for 18 hours, when the presence or absence of haemolytic streptococci was noted. When haemolytic streptococci were present, a rough estimate was made of the percentage of these organisms in relation to the total growth in order to give some idea of the degree of infection. It was realised that this method of measuring the degree of infection was open to the criticisms that results depended on the care with which swabs were taken and on fortuitous circumstances, such as a very localised focus of infection of the nose or throat being missed or not during the swabbing. All swabs (except in a few isolated instances) were taken, as carefully as possible, by one of us (W. A. B.) in order to eliminate variations associated with swabbing by different individuals.

Colonies were picked off from the plates which showed haemolytic streptococci and subcultivated into small tubes of nutrient broth containing 5 per cent. defibrinated rabbit's blood. After incubation at 37° C. for 18-24 hours, these subcultures were preserved in the refrigerator for 28 days, *i.e.* the period during which a return case might be notified. On the occurrence of an alleged return case, the strain of haemolytic streptococcus from the infecting case was typed serologically according to the technique described by Griffith (1926). At the same time, swabs were taken from each nostril and from the throat of the return case or cases, and the haemolytic streptococci isolated as before and typed. Careful clinical notes of each case were kept during the period of detention in hospital with particular reference to the occurrence of complica-

tions and the presence of morbid conditions on discharge. The condition of the tonsils was also noted when the patients were being discharged.

BACTERIOLOGICAL DATA

(1) *Carrier rate on discharge and infecting case rate*

During the investigation swabs were taken, immediately prior to discharge, from each nostril and from the throat of 808 scarlet fever patients. Table I shows the number of cases, in each consecutive series of 100 patients examined, where haemolytic streptococci were obtained in culture from the nose and/or throat and also the total figures for all the series. Separate figures for each nostril are not given as no essential difference was found (the actual figures were: right nostril, 26 per cent. positive; left nostril, 26·8 per cent. positive). The degree of variation between individual series is greatest in the figures

Table I. *Percentage of patients convalescent from scarlet fever showing Streptococcus pyogenes in the nose and/or throat on discharge from hospital*

Serial Nos. of cases	No. showing haemolytic streptococci in			No. showing absence of haemolytic streptococci
	nose	throat	nose or throat	
1-100	33	75	84	16
101-200	35	86	88	12
201-300	32	80	88	12
301-400	29	75	82	18
401-500	38	66	77	23
501-600	40	79	87	13
601-700	32	68	75	25
701-800	25	78	81	19
801-808	3	7	7	1
All cases	267	614	669	139
Percentage	33·0	75·9	82·8	17·2

for the throat, ± 10 per cent. of the average for the whole series. The high percentage of carriers (82·8 per cent.) was mainly due to the presence of haemolytic streptococci in the throat as only 33 per cent. had haemolytic streptococci in the nose. On the other hand, the proportion of patients (17·2 per cent.) showing a complete absence of haemolytic streptococci on discharge is surprisingly small. Gunn and Griffith (1928) in a series of 100 cases found a total carrier rate on discharge of 49 per cent., and Allison and Gunn (1932) in a series of 200 cases reported a rate of 52 per cent. The only difference in the technique of these two investigations and that of the present series is that in our series swabs were taken from each nostril but this would not entirely account for the higher figures now reported.

Thirty patients, out of the total (808) observed, became infecting cases following discharge, an infecting case rate of 3·7 per cent., and these (30) gave rise to forty return cases, a return case rate of 4·9 per cent. These figures are in agreement with observations made over a number of years indicating that the average rate of return cases is 4 per cent., but are difficult to reconcile with an average carrier rate on discharge of 82·8 per cent. Why does so small a proportion of carriers become infecting cases?

(2) *Infecting case rate and degree of infection on discharge*

The first point investigated was the possibility of connection between the degree of infection by haemolytic streptococci, as measured by the proportion of colonies on plate cultures, and the infecting case rate. With this object in view the series of 808 cases was divided into five different categories as follows:

- (1) *Negative*—no haemolytic streptococci present.
- (2) *Mild infection*—haemolytic streptococci present up to 25 per cent.
- (3) *Moderate infection*—haemolytic streptococci present, 25–50 per cent.
- (4) *Heavy infection*—haemolytic streptococci present, 50–90 per cent.
- (5) *Very heavy infection*—haemolytic streptococci present, over 90 per cent.

Table II. *The relation between the degree of infection and the infecting case rate*

	Degree of infection				
	Negative	Mild	Moderate	Heavy	Very heavy
No. of cases	139	337	133	120	79
Percentage	17.2	41.7	16.5	14.8	9.8
No. of infecting cases	4	10	4	7	5
Infecting case rate (%)	2.9	2.9	3.0	5.8	6.3

Table II shows the number of cases in the whole series grouped according to these categories. It will be seen that the majority of cases (41.7 per cent.) fall into the category of "mild" infection and that only 9.8 per cent. showed "very heavy" infection. When these figures are compared with the number of infecting cases, it is found that there is a definite relationship between the degree of infection and the infecting case rate. The sudden rise in the infecting case rate from 3 per cent. in those showing "moderate" infection to 5.8 per cent. in those showing "heavy" infection is noteworthy. The similarity of the infecting case rate (2.9 per cent.) in the "negative" and "mild" groups indicates that haemolytic streptococci were present, probably as a mild infection, in the "negative" group but were missed even under careful conditions of swabbing. The true carrier rate on discharge must therefore be still greater than the already high rate (82.8 per cent.) found in this series. The failure to isolate haemolytic streptococci from the "negative" patients who gave rise to return cases may have been due to (a) faulty swabbing, (b) a very mild infection or (c) the presence of a temporarily inaccessible focus of infection. The figures, however, indicate that, on the whole, the important consideration is the profusion of haemolytic streptococci in cultures from the nose and throat of the patient at the time of discharge, but that a negative bacteriological result does not preclude such a discharged patient from becoming an infecting case.

(3) *Serological type of Streptococcus pyogenes in infecting and return cases*

As already stated, past investigations into the question of return cases have been undertaken without the aid of bacteriological and serological methods. The occurrence of a case of scarlet fever in the same house following

a scarlet fever discharge, might possibly be due to mere coincidence. The suspicion that the two events are connected, is, of course, quite strong, but it is even more convincing when it can be shown that the serological type of haemolytic streptococcus in the alleged infecting case and in the corresponding return case is the same. An analysis of the serological types found in the infecting and the return cases in the present series is shown in Table III.

Table III. *The serological types of Streptococcus pyogenes present in infecting cases and in the corresponding return cases*

Infecting cases (30)		Return cases (40)	
No. of cases	Serological type on discharge	No. of cases	Serological type on admission
2	1	2	1
11	2	17	2
2	3	2	3
1	5	2	5
2	8	3	8
1	12	1	12
1	1 and 2	1	1
1	1 and 2	1	2
1	3, 8 and 11	1	3
1	2 and 8	1	8
2	<i>H</i>	2	<i>H</i>
2	—	2	2
1	—	2	3
1	—	1	<i>H</i>
1	4	1	2

H = heterogeneous strain (untyped).

In explanation of this table, it should be realised that the haemolytic streptococci found in scarlet fever belong to over twenty different serological types (Griffith, 1935). Some of these, *e.g.* types 1, 2, 3 and 4, are at present associated with about 70 per cent. of all cases of scarlet fever. The remaining 30 per cent. are caused by less common types of which 5, 8 and 12 are examples. On examination of the table it will be seen that twenty-six of the thirty infecting cases (86.6 per cent.) were carriers of haemolytic streptococci on discharge from hospital. This shows no significant difference from the carrier rate on discharge of 82.8 per cent. for the whole series. Type 2 was the commonest serological type present in the infecting and return cases (fourteen infecting cases out of thirty, and twenty-one return cases out of forty). In a few instances the infecting case was harbouring two or more serological types, and the corresponding return case became infected with only one of these. The term "heterogeneous" indicates types for which specific sera were not available at the time of investigation. In four instances return cases were ascribed to patients from whom no haemolytic streptococci were isolated on discharge from hospital. The possible reasons for these anomalous results have already been mentioned.

In one instance the alleged infecting case showed a type 4 infection, and the corresponding return case (his father), a type 2 infection. The son was swabbed twice weekly, for other reasons, throughout his stay in hospital and

he had a persistent type 4 infection during his whole illness. We can only assume that, in this particular instance, there was no connection between the discharged case and the return case. The possibility of the discharged case having a double infection due to types 2 and 4 was practically ruled out by reason of repeated swabs which gave cultures with the characteristic colony appearance of type 4, which is never assumed by type 2. Further evidence in support of a single type infection in this case was seen in the uninterrupted clinical recovery of the infecting case without evidence of secondary infection.

In all the remaining cases the serological type present in the infecting case was found in the corresponding return case or cases.

One particularly interesting case in the infecting group is worthy of special mention. On discharge, on the thirty-second day of disease, the patient was found to be a carrier of three distinct serological types:

Right nostril	75 per cent., type 3.
Left nostril	75 per cent., type 11.
Throat	75 per cent., type 8.

Four days later her sister was admitted with a pure type 3 infection. After an interval of 3 days, a second sister was admitted also with a pure type 3 infection. At the request of the local Medical Officer of Health, the infecting case, who had developed rhinorrhoea after return home, was readmitted and she was then found to be a carrier of type 3 only in both nostrils and in her throat. It would appear that, in the case of this family, the type 3 *Streptococcus* was more highly infective than the other two types present. Unfortunately, no information was available as to which of the three strains was the primary infecting type in the first patient, and which was the last acquired.

DETAILED ANALYSIS OF INFECTING CASES

What is the factor which determined the infectivity of these thirty infecting cases? Is there anything in the history, the clinical course, or the condition on discharge to explain it?

(1) *Relation between infectivity and duration of disease*

In Table IV, 808 patients are classified according to the week of disease in which they were discharged; this refers to the actual history of illness and not necessarily to the number of weeks in hospital. It will be seen that the percentage of cases carrying haemolytic streptococci on discharge is approximately the same in each group, but that the infecting case rate is highest among those who were sent home during the fifth, sixth and seventh weeks of disease. The infecting case rate for the fourth week is considerably lower and approximately the same as that found among those detained until the eighth and subsequent weeks. There is no correlation between carrier rate and infecting case rate, since the time of discharge from hospital which gives the lowest infecting case rate is the fourth week, at which time the carrier rate

is practically as high as at later dates with higher infecting case rates. On the other hand, the fall in infecting case rate among those discharged after 8 weeks or more may be explained by the inclusion among them of many patients whose discharge had been delayed because of ward quarantine, or minor intercurrent infections or complications, *e.g.* scabies, impetigo, vaginitis, etc. In both ward quarantine and isolation for intercurrent infections the patients differ from the normal in not having been in contact with acute cases of scarlet fever immediately before leaving hospital. The hypothesis may be

Table IV. *Relation of week of disease to carrier rate on discharge and to infecting case rate*

Week of disease on discharge	No. of patients discharged	Haemolytic streptococci		No. of infecting cases arising	No. of return cases admitted
		Absent	Present		
4th	73	15 20.6 %	58 79.4 %	1 1.4 %	1
5th	251	39 15.5 %	212 84.5 %	13 5.2 %	16
6th	191	37 19.4 %	154 80.6 %	8 4.2 %	15
7th	99	13 13.2 %	86 86.8 %	5 5.0 %	5
8th and upwards	194	35 18.1 %	159 81.9 %	3 1.5 %	3
Total	808	139 17.2 %	669 82.8 %	30 3.7 %	40 4.9 %

suggested that the normal course of events in a patient with a single scarlatinal streptococcal infection is that the streptococcal strain largely loses its infecting power during the fourth week, but that, in ordinary hospital practice, this period is the time at which reinfection with fresh strains from newly admitted scarlatinal cases occurs; these fresh strains require again something like 4 weeks to lose their infectivity. We intend to discuss this question of reinfection in scarlatinal wards and its effects in a future paper.

(2) *Complications during stay in hospital*

In the series of 808 patients examined, 565 remained free from complications throughout their stay in hospital and seventeen of these became infecting cases, an infecting case rate of 3 per cent. The remaining 243 patients showed complications and thirteen became infecting cases, an infecting case rate of 5.3 per cent. Examination of Table V shows that the most frequent complication in the infecting cases was secondary cervical adenitis. It was present in seven (23.3 per cent.) of the infecting cases in contrast to fifty-seven (7.3 per cent.) of 778 cases which did not give rise to return cases. The exact pathology of secondary cervical adenitis, like that of nephritis, has been the subject of considerable discussion. A possible cause is a reinfection of the throat by a different serological type of streptococcus from that which caused the primary attack of scarlet fever: this has already been shown to occur by Gunn and Griffith (1928). If this is so, then a case of scarlet fever complicated by secondary cervical adenitis should be an important potential source of in-

fection on discharge because the secondary infecting strain has had sufficient invasive power to overcome, to some degree, the immunity produced by the primary infecting strain and to produce a local inflammatory reaction associated, as a rule, with pyrexia.

(3) *Morbid conditions on discharge*

At present the absence of morbid conditions at the time of the patient's discharge is taken as the main evidence of freedom from infection. These morbid conditions are, we consider, for the most part, the consequence of complications occurring while in hospital. The complicated case is more likely to show foci of infection when otherwise ready for discharge.

Table VI shows that enlarged tonsils were noted in twenty (66.6 per cent.) of the infecting cases, either alone or in association with other conditions. One-third of the infecting cases had desquamation on leaving hospital; but the opinion of epidemiologists, confirmed by the work of Allison and Gunn (1932) on the rarity of haemolytic streptococci in desquamation scales, is that

Table V. *Nature of complications during hospitalisation in seventeen infecting cases*

No of cases	Secondary cervical adenitis	Nephritis or late albuminuria	Rhinitis	Otitis media	Vaginitis
5	+	-	-	-	-
2	-	+	+	-	-
2	-	+	-	-	-
1	+	+	-	-	-
1	-	-	+	-	-
1	+	-	-	+	-
1	-	-	-	-	+
17	-	-	-	-	-
30	7	5	3	1	1

Table VI. *Morbid conditions present on discharge in thirty infecting cases*

No. of cases	Enlarged tonsils	Desquamation	Palpable glands	Rhinorrhoea
7	+	-	-	-
6	+	-	+	-
5	-	+	-	-
4	+	+	-	-
2	+	-	-	+
1	+	+	+	-
5	-	-	-	-
30	20	10	7	2

this condition is most unlikely to be a source of infection. The rarity of rhinorrhoea and the absence of otorrhoea will be noted. This is due to the fact that, as far as possible, patients suffering from these complications are detained until the discharge has entirely ceased.

(4) *Sex and age*

Consideration of the sex of the infecting cases showed that there were more male infecting cases than female. The actual difference was not great (M. 17, F. 13) but produced an infecting case rate showing a definite male pre-

ponderance (M. 4.6 per cent., F. 2.9 per cent.). This result was not expected in view of the prevalent opinion that females are more likely to convey scarlet fever infection than males.

As regards the influence of age the greatest number of infecting cases fell into the age group 5-10 years; the actual figures were 339 discharges, 15 infecting cases, an infecting case rate of 4.7 per cent. This is in accord with the results of Cameron (1905). On the other hand, the infecting case rate for children under 5 years was 3.8 per cent., and for patients over 14 years, 2 per cent. These figures are at variance with those of Gordon and Badger (1934), who stated that the infecting case rate in children under 5 years was eleven times that of patients over 14 years. On considering age and sex together, it was found that in the age period of highest infecting case incidence (5-10 years) the preponderance of males was even more pronounced (M. 6.8 per cent., F. 2.5 per cent.).

(5) *Interval between infecting case and return case*

The interval which elapsed between the arrival home of the infecting case and the occurrence of the corresponding return case or cases varied considerably, the shortest period being 3 days, and the longest 27 days. Thirty per cent. of the cases occurred within 4 days and 70 per cent. within 14 days. In the majority of instances, information elicited from the parents or guardians failed to reveal the occurrence of any morbid condition in the infecting case following the arrival at home, but in a few cases the parents stated that nasal discharge had appeared within a few days of discharge from hospital.

(6) *Home conditions*

In 275 of the 808 discharged patients, the parents were interviewed and information obtained on the type of house to which the patient was returning. The points enquired into were the number of rooms and the number of probable susceptible children (*i.e.* those having no history of scarlet fever) under 15 years. The information thus obtained did not provide any reliable basis for the prediction of probable return cases, as is shown by the examples in Table VII.

(7) *Tonsillectomy*

The possibility that a history of tonsillectomy might render a patient less liable to show a high percentage of haemolytic streptococci in the throat on discharge was investigated. It was found that ninety patients out of 756 in the series had a history of tonsillectomy. The time of operation varied from a few days to 30 years before the onset of scarlet fever, the majority of cases having had the operation within 5 years. It was found that the percentage of haemolytic streptococci in the throats in these patients was not lower and the incidence of infecting cases was actually higher than in the non-tonsillectomised group (4.4 and 3.6 per cent. respectively). The value of these results

was minimised by reason of the fact that in a large number of these cases with a history of tonsillectomy there was evidence of a considerable amount of persisting tonsillar tissue and in some instances, indeed, marked enlargement of the tonsils was recorded in the clinical notes at the time of discharge.

Table VII. *Examples of home conditions in relation to infection on discharge and the occurrence of return cases*

Infecting case		Proportion of haemolytic streptococci in cultures from			Home accommodation (rooms)	Total number of		
Sex	Age (years)	right nostril %	left nostril %	throat %		Persons in house	Susceptibles in house	Return cases
M.	7	20	5	10	4	6	3	3
M.	8	—	—	30	4	8	5	0
F.	6	—	—	5	7	6	3	3

(8) *The effect of serum treatment*

Of the 808 cases, 230 were treated with scarlatinal antitoxin by the intramuscular route (average dose 15 c.c.). The cases so treated were those of the more severe type and the incidence of complications was higher than in the non-serum treated group. In spite of this, the infecting case rate in the serum treated cases (2.1 per cent.) was less than half that of the group in which the administration of antitoxin was not considered necessary (4.3 per cent.).

DISCUSSION

The epidemiological features of scarlet fever in this country at the present time are very different from those of the last century. Although the seasonal prevalence is unchanged, there is nowadays no tendency for a severe type to appear in epidemic periods and the characteristic feature of the disease is its mildness. In spite of this the return case rate remains approximately the same (4-5 per cent.).

We agree with Gordon (1932) that the return case rate is a less accurate index of the efficiency of hospital administration in relation to discharge of scarlatinal patients than the infecting case rate, since the number of cases an infecting case produces depends on fortuitous circumstances. But Gordon's definition of the infecting case as one giving rise to another or other cases in the *immediate family*, though the only practicable one, fails to take into account the other possibilities, viz. infection in school, tenement or street. Some of these possible infections may, in future, be traced by the use of serological identification of type.

The carrier rate of haemolytic streptococci for 808 patients discharged convalescent from scarlet fever was 82.8 per cent. This was unexpectedly high and was independent of the period of detention in hospital from the fourth to the eighth week and upwards. The number of discharged patients who became infecting cases was thirty, an infecting case rate of 3.7 per cent., and these gave rise to forty return cases (return case rate 4.9 per cent.). When

these figures are coupled with the fact that no haemolytic streptococci were isolated from four discharged patients who subsequently became infecting cases, it seems certain that the true carrier rate must have been still higher.

When the patients were classified according to the degree of infection present on discharge, as shown by the proportion of haemolytic streptococci present in swab cultures, it was found that, while patients free from haemolytic streptococci or having only a "mild" or "moderate" degree of infection showed an infecting case rate of 3 per cent., those with a "heavy" or "very heavy" infection had infecting case rates of 5.8 and 6.3 per cent. respectively. The infecting case rate, therefore, does not appear to depend so much on the number of carriers discharged as on the degree of infection present in individual cases. During the investigation it was found that some uncomplicated cases, which were clinically satisfactory on leaving hospital, had a very heavy infection with haemolytic streptococci in the nose and/or throat. In cases such as these bacteriological examination offers the only definite evidence of possible high infectivity. But the converse condition was also found, *i.e.* cases which were not ready for discharge on clinical grounds, *e.g.* on account of rhinorrhoea, otorrhoea, etc., and yet showed absence of or very scanty haemolytic streptococci. These findings demonstrate the failure of clinical examination as an index of freedom from infection. But bacteriological findings are not more conclusive, since a child with a profuse rhinorrhoea containing scanty streptococci may be just as dangerous as a non-catarhal child reported as having a heavy infection with haemolytic streptococci. It appears, therefore, that, in the main, bacteriological control alone can offer little help either in detecting probable infecting cases prior to discharge from hospital or in indicating when a patient should be discharged. As hitherto, the main criterion for discharge of scarlatinal convalescents must be the clinical condition. The practical value of swabbing all scarlatinal patients prior to discharge would not be commensurate with the amount of work involved. These views are supported indirectly by the findings of Gordon (1932) who was able to demonstrate only 266 haemolytic streptococcal carriers (9.1 per cent.) out of a total of 2915 patients swabbed prior to discharge; 110 of these 2915 patients became infecting cases and no fewer than ninety-six of them had been found free from haemolytic streptococci on discharge. Hoyne and Bailey (1934) in America, have discharged patients on negative bacteriological findings, taking swabs on the nineteenth day of disease. In the light of the present investigations it seems surprising to expect haemolytic streptococci to be absent at this stage. In a collateral investigation, we swabbed the patients in a 23-bed scarlet fever ward bi-weekly for a prolonged period and at the end of the nineteenth day of disease only three patients (6.1 per cent.) out of a total of forty-nine were found to be free from haemolytic streptococci. In how much this persistence of a high carrier rate is due to reinfection by contact with fresh admissions remains to be determined. It may be that segregation of 2-3 week convalescents in separate wards would greatly diminish it.

The notification of a return case of scarlet fever has almost invariably been accepted as an indication that the supposed infecting case was a carrier of scarlatinal infection at the time of leaving hospital. Serological identification of the strains of haemolytic streptococci in the infecting and return cases has shown that this attitude is justified in almost all instances. It cannot be accepted as entirely conclusive, however, since the return case may occasionally derive his infection from a different source. This possibility is even more obvious if the serological type of *Streptococcus* isolated from the return case is one which is epidemic at the time.

The period which elapses between the arrival home of a patient and the occurrence of a return case may be of value in the determination of cause and effect. At most London fever hospitals instructions are issued to parents to keep the discharged patient apart from other children in the home for 3 weeks and away from school for 2 weeks. It is impossible to say whether these instructions are carried out precisely or not—on the whole, probably not. The social status of a large number of the patients admitted to the fever hospitals is low and in many instances the application of the advice given on discharge is impracticable. It is probable that where the relationship between infecting and return case is direct, the disease develops in the return case within 2–3 days of exposure to the discharged patient; a longer interval elapsing between the arriving home of the infecting case and the onset of scarlet fever in the return case is probably due, in most instances, to the observance of instructions as to home isolation.

The complicated case of scarlet fever has always been regarded as a potent source of infection, mainly owing to the belief that rhinorrhoea means infectivity. But a considerable number of scarlet fever patients are detained in hospital on account of serous rhinorrhoea, which in many instances may be shown by bacteriological methods to be non-infectious. Gordon has shown that serous nasal discharge (coryza) occurring in the course of an attack of scarlet fever was not an important factor in the production of infecting cases. Actually he found that the infecting case rate was slightly greater in the uncomplicated group than in those in whom coryza was present as a complication. In practice we found that haemolytic streptococci were frequently absent in cases of coryza among scarlatinal convalescents. In a few instances we were informed by the parents that the infecting case had developed a nasal discharge after return home. This development of late rhinorrhoea was not necessarily a recurrence, and it is possible that alteration in the temperature of rooms at home, chill contracted during the journey from hospital, or a simple infection with the unknown agent of coryza may have played some part in its production. We feel, however, that if a child is carrying haemolytic streptococci in the nose or throat and a simple catarrh supervenes it obviously renders him likely to be a much more important spreader of infection, and that, from this point of view, serous nasal discharge should be regarded with suspicion.

Gordon (1932) found an infecting case rate of 2·4 per cent. in uncomplicated cases in contrast to a rate of 6 per cent. in complicated cases. In our series 565 cases showed no complications and seventeen of these became infecting cases (3 per cent.), whereas 243 cases were complicated and thirteen infecting cases arose (5·3 per cent.). As has been shown, the commonest complication in these infecting cases was secondary cervical adenitis (23·3 per cent.). The occurrence of this complication seems to have some connection with re-infection of the throat and with the condition of the tonsils. As a result of observations before, during and after an attack of scarlet fever, it has been found that the size of the tonsils usually increases during the period of infection, and this may explain the tonsillar enlargement found in a considerable number (66·6 per cent.) of the infecting cases in this series. On the other hand, there was no evidence to show that a previous tonsillectomy rendered a patient less likely to be a source of infection, although in four tonsillectomised infecting cases in the series, the degree of throat infection was "negative" (one case), "mild" (one case) and "moderate" (two cases). On the whole, the enlarged tonsil is more likely to be the seat of infection with *Streptococcus pyogenes* than the normal.

It is somewhat surprising that the child over 5 years of age should be a greater source of infection than the child under this age when one considers the probability of closer contact with home susceptibles in the younger age group. If the term "return case" included patients admitted from the same school as the infecting case, then it is probable that the school-age group 5-10 years would show a still higher infecting case rate.

The influence of home conditions, overcrowding, etc., on the infecting case rate is extremely difficult to assess. That an absence of a history of scarlet fever is not a reliable guide to susceptibility must be admitted. Children of the poorer classes are frequently exposed to subinfective doses of haemolytic streptococci and may develop an active immunity without having had the disease. A record of three or four susceptibles (on the basis of no history of scarlet fever) may therefore be entirely erroneous. On the other hand, in a house containing several susceptibles, the instructions as to home isolation may be strictly followed and this may result in the prevention of return cases. In the enquiries which we made into this aspect of the question it was impossible to obtain information concerning susceptibles at home; all we could do was to regard as susceptibles all children under 15 years who had no history of scarlet fever. Parsons (1927) issued a questionnaire on this point to a large number of public health authorities, and the information obtained suggested that there was no definite connection between overcrowding and the occurrence of return cases.

The administration of scarlatinal antitoxin has now become common practice; it is given either to all cases without discrimination or only to those in whom the disease appears to be severe. There is no *a priori* reason why antitoxic serum should have a direct effect on the number of haemolytic

streptococci in the nose and throat. If then the percentage of haemolytic streptococci in the nose and throat of a scarlet fever patient is not reduced by the injection of antitoxin, a serum-treated patient should be just as likely to become an infecting case as one to whom serum was not given. It must be realised, however, that if the incidence of complications is reduced in serum-treated cases, the number of open foci discharging infectious material will also probably be decreased; *i.e.* the likelihood of the patient becoming an infecting case will be correspondingly less.

The advantage of early discharge in scarlet fever is indicated by the low infecting case rate of patients released from isolation during the fourth week of disease. Detention beyond this stage results in a higher proportion of infecting cases until the eighth week, when the rate again falls. There is therefore nothing to be gained by isolation beyond the fourth week of disease. It is understood, of course, that the presence of complications such as rhinitis, otitis media, etc., in these early weeks entails longer hospitalisation. One complication which may arise unexpectedly is nephritis, and it is the possibility of this occurring in an otherwise uncomplicated case which necessitates observation in hospital until the end of the third week. Our opinion is that if nothing abnormal is revealed by urinary examination on the twenty-first day of disease the patient should be discharged if his condition is otherwise satisfactory (*i.e.* actual discharge on the twenty-third day of disease allowing the usual 2 days' notice to parents). It is advisable to make a final urinary examination on the morning of discharge.

It is interesting to note that the bacteriological study of carriers in relation to infectivity entirely confirms the views of the older epidemiologists as to the connection between the discharged case and the return case in scarlatina.

SUMMARY

1. In view of the high carrier rate on discharge from hospital, the bacteriological examination of swabs from scarlet fever patients is of no value in the detection of probable infecting cases.

2. There is, however, a definite relationship between the degree of infection, as measured by the profusion of haemolytic streptococci in cultures on discharge, and the likelihood of the patient infecting others.

3. The causal connection between "infecting" case and return case is strongly supported by finding the same serological type of *Streptococcus pyogenes* in both cases.

4. A patient who has had complications in hospital is slightly more liable to become an infecting case than one whose course has been uncomplicated.

5. The commonest age group of infecting cases is 5-10 years.

6. The majority (70 per cent.) of the return cases occurred within 14 days of the arrival home of the infecting case.

7. Overcrowding in the home, and the number of the susceptibles exposed do not appear to be important factors in the production of return cases.

8. A history of tonsillectomy does not appear to bear any important relationship to the occurrence of infecting cases, but the inconclusive nature of our findings indicates the desirability of further investigation of this question and that of the relation of the condition of the tonsils to their infectivity.

9. Discharge from hospital as early as is consistent with a satisfactory clinical condition is shown to be advantageous from the point of view both of the patient and of the hospital administration.

10. The administration of scarlatinal antitoxin is likely to render a patient less liable to convey infection on discharge.

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