BACTERIOLOGICAL AND EPIDEMIOLOGICAL STUDIES OF STREPTOCOCCAL INFECTIONS

WITH PARTICULAR REFERENCE TO EPIDEMIOLOGICAL ANALYSES BY SEROLOGICAL TYPING OF HAEMOLYTIC STREPTOCOCCI.

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INTRODUCTION.

The haemolytic streptococcus has assumed considerable importance during recent years. From the multiplicity of lesions it may produce it undoubtedly deserves this widespread recognition. As early as 1900 Baginsky and Sommerfeld recorded the presence of this organism in each of 700 cases of scarlet fever. Hektoen (1903) reported the isolation of streptococci from the blood in twelve per cent of scarlatinal patients and noted that their presence was not necessarily of bad prognostic significance. Despite these observations there was considerable hesitation in accepting the streptococcus as the causative organism of scarlet fever. The work of Gabritschewsky (1907) on the immunising effects of streptococcal vaccine; of Moser (1902), some years before, on the therapeutic action of anti-scarlatinal serum in the human disease; of Krumwiede, Nicoll and Pratt (1914), who recorded a case of scarlet fever in a technician, who had accidentally sucked into his mouth a suspension of live streptococci; and finally that of Dick and Dick (1921, 1924 (a) (b), 1925 (a) (b)), and Schultz and Charlton (1918) on the action of toxic filtrates of haemolytic streptococci, and immune serum when injected intradermally, all aided in establishing the view that scarlet fever was due to the haemolytic streptococcus.

With regard to the other types of infection with this bacterial species Butler (1909) called attention to the frequency with which tonsillitis occurred in the families in which one or more members had scarlet fever, and he suggested that the same organism was the incriminating factor. During recent years the epidemiological evidence in favour of this fact has been much strengthened by the work of Glover and Griffith (1931), and Griffith (1934), who showed a relationship between scarlet fever and tonsillitis occurring in closed communities, such as schools. The study of milk-borne epidemics by Davis and Rosenow (1921), by Stokes and Hachtel (1912), and by Coleman and Wheeler (1926) was in full support of Butler's views.

As long ago as 1887 Meierowitsch (1888) and later Gromakowsky (1895) noted the relationship between the streptococcus and erysipelas.

The association between this organism and puerperal fever was proved by the London and North England Committee (1925), and by the investigations of Fitzgibbon and Biggar (1925), Colebrook (1926), Kinloch et al. (1928), Dora C. Colebrook (1935) and numerous other workers.

The results of the early attempt at classifying the haemolytic streptococci are much at variance with one another. Of the methods devised for such a classification, that based on the agglutination reaction

has found most favour. As early as 1902 Moser and von Pirquet used direct agglutination with sera from scarlet fever patients and also from the horse, immunised with haemolytic streptococci, which they had isolated from the blood of fatal cases of scarlatina. They arrived at the conclusion that the strains found in scarlet fever formed a distinct serological group. This was confirmed by Meyer (1902), Rossiwall and Schick (1905). Their findings were, however, disputed by Aronson (1903), who employed the same technique as that used by Moser and von Pirquet. Likewise Neufeld (1903) cast considerable doubt upon the validity of the earlier work. In his investigation he employed immune rabbit serum.

After this initial impetus the study of serological classification was lost sight of until the subject was once more opened by Dochez, Avery and Lancefield (1919). By an investigation of 125 strains of haemolytic streptococci associated with respiratory infections, they showed by means of the agglutination reaction that these could be subdivided into at least four definite biological types.

The following year Tunnicliff (1920) and Bliss (1920), and later Gordon (1921) showed that at least 80 per cent of scarlatinal strains were of one serological type. This observation did not remain unchallenged. Williams (1924) showed that a multiplicity of types existed, of which the largest constituted only

15 per cent of all the strains examined. The importance of his work was enhanced by his discovery that strains identical with those found in scarlet fever, were also responsible for other haemolytic streptococcal infections, like puerperal fever and erysipelas.

These observations were confirmed by other observers (Smith (1926,1927), MacLachlan and Mackie (1928)).

At the same time the above workers were carrying out their investigations Griffith (1926) examined, by means of slide-agglutination, a hundred strains of scarlet fever and found that the majority belonged to four types. The following year (1927) he published a comprehensive monograph, in which he produced evidence that 60 per cent of all strains found in acute scarlatina belonged to one or other of types 1, 2, 3 and 4 of his classification, which is now comprised of 30 types.

Andrewes and Christie (1932) established the presence of three of the four types originally described by Griffith, while the whole of his results were confirmed by Allison and Gunn (1932). Slide agglutination method of typing haemolytic streptodocci in which absorbed antisera are used, has made it possible to type the majority of organisms.

Lancefield (1928) demonstrated the presence of a type-specific substance, of protein character, in

haemolytic streptococci, and developed a method of classification based on the precipitin test. Coburn and Pauli (1932) applied this method to strains isolated from the throats of rheumatic subjects during attacks of pharyngitis and found a number of serological classes of haemolytic streptococci. They found, however, that complete classification was impracticable, since cross-reactions, due to the high concentrations of carbohydrate antibody (Anti-C) in some of the rabbit anti-sera confused the results obtained.

Lancefield improved on her technique. A general agreement between her precipitin methods and Griffith's slide agglutination was shown to exist, (Swift, Lancefield and Goodner (1935)). Lancefield (1933) has made it possible to identify strains pathogenetic to man (Group A). It has been found that most of Griffith's types are included in Lancefield's Group A (Pauli and Coburn (1937)). The four exceptions are 7, 16, 20, 21. Of these 16 belongs to Group G and the others to Group C.

One of the main difficulties encountered in Griffith's method of typing is the spontaneous agglutination which the organisms tend to undergo. This problem has been investigated by numerous workers. In order to avoid this agglutination occurring Dochez, Avery and Lancefield (1919), Bliss (1922), Durand and Sedallion (1925), and Rosner (1928) grew antigen in a

salt-free medium containing phosphate-buffer; Tunnicliff (1922) used ascitic-broth plus glucose; Gordon (1921) used trypagar plus ascitic fluid; Shipley (1924) allowed the organisms to grow at room temperature; Smith (1926) suspended washed organisms in 0·001 N/1 NaOH and diluted the immune serum with M/320 NaCl solution; James (1926) grew organisms first in salt-free meat-infusion broth, then transplanted them to tryptic digest broth; Noble (1927) used serum and antigen in a more concentrated form than is usual, reading the results after the mixture had been shaken for two minutes; Stephens and Dochez (1926), Spicer (1930) and Williams and Gunley (1932) added strips of sterile potato to phosphate-buffered broth; MacLachlan and Mackie (1927) used phosphate-buffered broth plus glucose; Gunn and Griffith (1928) and Allison (1931), Mueller and Klise (1932) diluted immune serum with physiological saline containing 2 per cent normal horse serum. Although most of these methods gave a certain measure of success they did not solve the problem. Their very numbers indicate the difficulty experienced in obtaining homogeneous growths for the purpose of making accurate readings of the presence of agglutination.

In addition to the serological methods of classification others have at different times been tried with variable success. Fermentation reactions, capsule formation, colonial variation, and phage differentiation have all been the basis of classification. With

the exception of the last-named, and studied by Kendrick and Hollon (1931), Lancefield (1932), Levine and Frisch (1935), Evans (1935), and others, they are of little value in type differentiation.

Of all the methods Griffith's slide agglutination remains the most practicable for epidemiological work. It is rapid, simple and the results are fairly constant.

The serological investigation of the types concerned in small epidemics of scarlet fever had been studied by Glover and Griffith (1931) and Griffith (1934), but the first investigation on a large scale was carried out by Green (1937) during the epidemic of 1933 in Edinburgh. He found that types 1,2,3,4 and 5 were the epidemiological strains, in which 5 predominated. Recently Neisser (1939) has carried out a survey of 1,211 strains of haemolytic streptococci found in scarlet and puerperal fevers and vulvo-vaginitis. She has attempted to trace the sources of infection in each of these.

The typing of haemolytic streptococci has made it possible to get a clearer understanding of what is meant by cross-infection among scarlet fever patients. When a patient is admitted into a ward he is infected with a particular serological type of Str. pyogenes and during his stay in hospital he may become secondarily infected or reinfected by a different serological type of this organism from other patients in the ward.

That more than one type may be found in the throat of a scarlet fever patient after he has been in hospital for some while, was observed by Gunn and Griffith and by Allison and Brown (1929, 1932).

That the alteration of types in a single patient is not likely to be due to transmutation of type has been indicated by the same workers.

The problem of air infection by haemolytic streptococci was investigated by Cruikshank (1935), White (1936) and Brown and Allison (1937). Allison and Brown (1937) made a detailed study of 47 cases of scarlet fever and showed that 70.2 per cent became re-infected with new types of haemolytic streptococci. They further showed that the majority of complications in multiple-bed wards devoted to scarlet fever, are due to reinfection. They showed further that most of the complications occurred during the third week, when the majority of the patients were convalescent. Their assumption is that the larger number of the complications arise from direct contact.

The carrier problem has received much attention. Williams (1924) noted that after 30 days in hospital only 20 per cent of convalescents were carriers. Kirkbride and Wheeler (1930) found that between 50 and 60 per cent were carriers after the same period. Gunn and Griffith's (1928) figures were 49 per cent, whereas Brown and Allison (1935) placed them at the

high level of 82.8 per cent of all patients, irrespective of the length of hospitalisation, when they were ready to be discharged. Kirkbride and Wheeler made the important observation that little difference in the virulence of haemolytic streptococci was found between the strains isolated from acute and convalescent cases. With regard to return cases Brown and Allison observed that a correlation existed between the degree of infection of cases leaving hospital with haemolytic streptococci in their throats and the return case rate. This was found to be 3 per cent in mild and moderate, but 6 per cent in heavy and very heavy infection.

This then is the position to-day. It is known that cross-infections among scarlet fever patients are due to new types. Brown and Allison (1937) assume that direct contact is the chief factor in producing this cross-infection. Their evidence, however, is not definitely conclusive. They recognise the fact that air-transmission of haemolytic streptococci may be an important factor, but their investigations do not preclude the fact that it may be as important or more important a factor than direct contact.

I have been unable to find any reference to correlations between the intensity of air-contamination in certain parts of the wards and the complication rate in such parts.

A problem that has not received much attention in all the above writings mentioned, is that of the effects of variations of ventilation in the contamination of the air.

Another problem that does not appear to have received much attention is that of the mechanism of the variations of the types found in the throats of scarlet fever patients as determined by daily swabbings over a long period.

Other points that appear to have received but little attention are the correlations of types with the various complications; of the correlations of types with length of hospitalisation; of the correlations of air-borne types with the types found in various haemolytic streptococcal infections; the comparison of types found in the throat and nose of scarlet fever cases and those repeatedly exposed to streptococcal infection.

The object of this research has been to investigate these problems and others, and at the same time to reinvestigate as much of the problem of epidemic and endemic streptococcal infections as time will permit.

With these objects in view it is hoped that certain general conclusions may be drawn indicating what methods could be adopted in order to reduce the number of complications which occur among the patients in scarlet fever wards.

Early in this work certain difficulties presented themselves: these were bacteriological, epidemiological and clinical.

Bacteriological Difficulties.

The problem of typing all the haemolytic streptococci found in the throats of scarlet fever cases is not yet solved. The fact that certain technical difficulties are encountered in typing the strains, is due to our insufficient state of knowledge regarding the typing of those strains which gave granular growths on culture. Such cultures are quite unsuited for the slide-agglutination method of typing. Although about 80 per cent of cultures can be typed, what the remaining 20 odd per cent indicate is a problem which requires further investigation.

Whether this untyped percentage of cultures would seriously affect the conclusions drawn from this research, if they were typable, is difficult to assess. Sufficient date has, however, been obtained to indicate the bacteriology of scarlet fever.

Other technical difficulties which present themselves in a research of this nature will be mentioned later.

Epidemiological.

The Epidemiological problems are numerous; perhaps the most important of these, from the point of view of this work, is that during an epidemic, there

is an increase of cases of streptococcal infection, to such an extent, that it becomes difficult to type all the cases during the time at one's disposal. It may be argued that all cases need not be typed to bring into relief the bacteriological picture on the epidemiological background. This is correct if it is desired only to know the epidemiological strains of haemolytic streptococci involved. But there is another problem: if all cases entering the scarlet fever wards were not typed there is the possibility of missing certain cases due to strains of haemolytic streptococci, which, although not of the epidemiological types, produce a rapid spread of complications among the cases in the wards. If such cases are missed the problem of tracing the organisms to particular patients or to localities, becomes almost impossible.

Another factor, which presents the greatest difficulty, is that epidemics or sporadic cases of scarlet fever may occur as the result of infection from normal carriers of the causative organism, or from cases presenting other clinical manifestations. To locate more than a few such cases proved quite beyond the scope of the present enquiry. That this is a problem of the utmost importance cannot be doubted. From the ubiquitous nature of the haemolytic streptococcus and the multiplicity of its pathogenesis it is clear that the prophylaxis against scarlet fever and its complications is not a matter of

isolating and studying such cases alone whilst ignoring that other vast field of infection.

To fully investigate all the cases of puerperal fever, erysipelas, rheumatic fever and the other haemolytic streptococcal infections, and correlate them with scarlet fever, can only be done by the combined effort of a team of workers, who devote a considerable proportion of their time to the subject.

Certain families have children who attend different schools. In such cases there is frequently the difficulty of determining from which school the infection was borne, should more than one member of the family contract scarlet fever.

Although an attempt has been made to investigate how the disease spreads from one section of the community to another, the results have not been entirely satisfactory. There must remain an element of uncertainty of the conclusions drawn from the enquiry; for in a freely mixing population it is wellnigh impossible to check and record in a practicable manner all the contacts of cases during their pre-infection stage. The free intercourse and contact of convalescent cases with one another, whilst in hospital, made the study of cross-infection a different problem.

Clinical.

The administration of streptococcal antiserum in certain cases, which on entry showed somewhat severer symptoms than the average case, frequently obscured a

true recognition of those types of haemolytic streptococci which produce the more violent forms of the disease. On the other hand the withholding of serum from the milder cases, which, shortly after entry to hospital, showed an aggravation of symptoms, even further confused the correlation of organismal types with the clinical manifestations.

In a number of cases showing complications more than one of Griffith's types were found in individual patients. From a purely clinical point of view it was difficult to ascertain which of the types accounted for the complications. Bacteriological methods were of little avail and it was only by statistico-clinical means that any conclusions whatsoever could be drawn.

These brief notes are not intended to indicate all the difficulties which this research met with. The object is only to point out the type of difficulty which occurred.

P A R T I.

PREPARATION OF TYPE-SPECIFIC ANTISERA.

(A) Vaccine Preparation.

(1) Horse-muscle trypsin-digest broth was used in order to obtain suitable growths for the preparation of the vaccines:

Thirty screw-top bottles, each containing 400 cc. of the medium, were inoculated with the thirty strains of haemolytic streptococci, obtained from Dr.Griffith, one strain to each bottle. They were then incubated for 18 hours at 37° C.

All the bottles, except those containing types 5, 9, 11, 14, 19, and 30 showed good growths, and were removed from the incubator for further treatment. The remaining six bottles showing poor growth were incubated for a further period of 18 hours.

(2) The bottles were allowed to stand for 24 hours at room temperature. The majority of the suspensions sank to the bottom of the bottles, leaving a clear supernatent broth, which could readily be siphoned off with the apparatus indicated in Figure I. The advantage of having such an apparatus to withdraw supernatent fluid is that is does not create a disturbance in the deposit - a trouble which is frequently encountered with in the ordinary pipette.

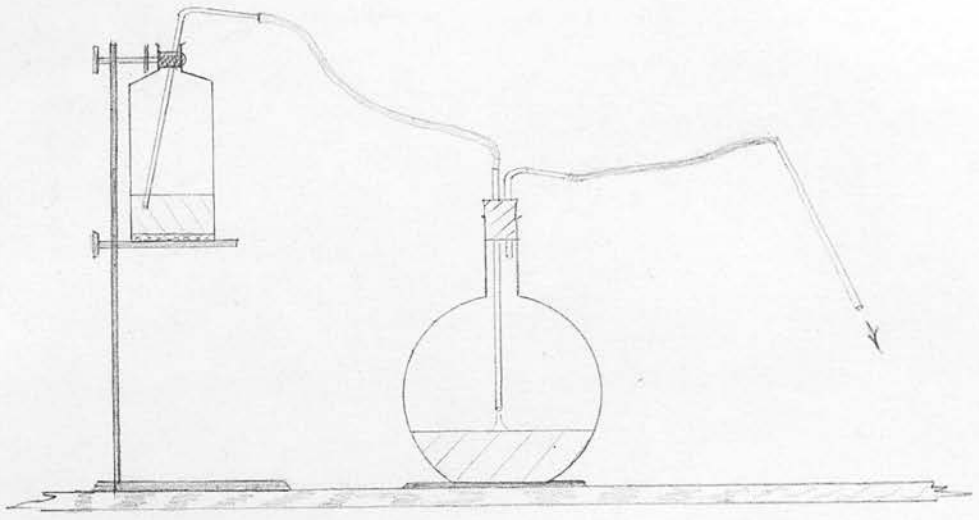


Fig. I

The object of freeing the organisms as far as possible from broth was to facilitate their subsequent centrifugalisation.

Those cultures which showed homogeneous suspensions were pipetted into sterile 250 cc. centrifuge-bottles; whereas the suspensions were pipetted into sterile thick glass 50 cc. test-tubes. Bottles and test-tubes were covered with rubber caps.

(3) All the organisms were spun down and broth decanted. The bottle sediments were then mixed with small quantities of sterile saline and converted to 50 cc. test-tubes.

The thirty test-tubes were half-filled with saline, their caps replaced and then thoroughly shaken. They were again centrifuged and decanted after which fresh saline was added. The process was

repeated three times to ensure the complete removal of the broth and the organismal products.

(4) To each of thirty sterile vaccine bottles, containing a few glass beads, was added 0.4 cc. of a 1% solution of formalin. The bottles were labelled 1 to 30. 20 cc. of saline was added to each of the thirty test-tubes of washed organisms; they were shaken and poured into the corresponding vaccine bottles. Rubber caps were fitted which were secured by fine copper wire.

The vaccines were then incubated for 24 hours at 37° C.

(5) Sterility tests were then performed, by withdrawing a small quantity from each bottle with a sterile needle and syringe and stroking this out on a blood-agar plate. The bottles were then sealed in molten wax, and the blood-agar plates incubated for 24 hours.

All the vaccines except Number 4 were sterile. This bottle was placed in a water-bath at 60° C. for half-an-hour, after which it was tested for sterility. No live organisms were found.

(6) Each cc. of vaccine corresponded to 20 cc. of broth culture.

(B) Animal Inoculation.

(1) The original plan was to inject rabbits with the vaccines for three consecutive days each week for six weeks (commenced 23/10/37). The marginal vein of the ear was chosen as the site of inoculation, and the following dosage table drawn up:

1st. week:	0.25,	0.25,	0.25 cc.
2nd. week:	0.25,	0.25,	0.3 cc.
3rd. week:	0.3,	0.3,	0.4 cc.
4th. week:	0.4,	0.5,	0.5 cc.
5th. week:	0.5,	0.5,	0.6 cc.
6th. week:	0.75,	0.75,	1.0 cc.

(2) Results of adhering to this scheme:

In a large proportion of cases, the animals died early in the experiment.

In a number of cases the animals refused to eat and a rapid loss of weight occurred. Such rabbits usually died.

It was found that the vaccines 1, 4, 5, 14, 19, 20, 24, 26, 27, 29, and 30, were particularly toxic in their effects.

It therefore became evident that such a set scheme of inoculation was unsatisfactory. The condition of the animals was thus taken as a better estimate for increase of dosage.

An attempt was made to obtain only rabbits that were full-grown and healthy. (The brown, wild rabbit

was found to do best.) They were weighed before injection commenced and then subsequently at weekly intervals. If they were losing weight the doses were withheld. In some cases it proved better to discard the rabbits and start with new ones. By this method a period longer than six weeks naturally resulted for the rabbits to develop antiserum with a sufficiently high titre. One serious drawback to this slower method of immunisation came to light. The sera showed a considerable increase of the "C" factor, nearly every such serum having this group agglutinin. On the other hand, if the animals stood the doses well, the quantities injected were rapidly increased, and in some cases a highly efficient antiserum was obtained after three or four weeks. Such antisera, on the whole, required little or no absorption.

At varying periods during the process of immunisation blood was withdrawn from the ear and sera tested for their agglutinating powers. When these were found satisfactory, all the blood was withdrawn by heart puncture and the animals so destroyed. At first only some of the blood was withdrawn, but a number of these animals died, and so valuable antisera was lost. In a few cases an insufficiency of blood had been taken and new rabbits had to be immunised.

On 10/11/37 the coke-stove, heating the animal-house, liberated carbon monoxide gas through a leak,

into the building and so destroyed the rabbits. The experiments had to be commenced afresh.

(Details of the animal experiments will be found in Appendix A.)

(3) Summary of Animal Experiments.

121 rabbits were used in the preparation of type-specific anti-sera:

Number of Rabbits used.	Vaccine Types.
2	2,3,13,15,18,22,23,25,28.
3	6,7,8,9,10,11,12,17,21.
4	16.
5	1,14,26,27.
6	20.
7	5,19,24,29.
9	4,20.

From these figures it will be seen that the last six vaccines alone accounted for the death of 46 rabbits.

The original vaccines 13 and 19 were found to produce practically no type-specific agglutinins. Subculture on blood-agar containing 10% specific sera (obtained from Griffith) produced two types of colonies with these strains: the one type was opaque, the other clear and smooth. Vaccines were prepared from both types of colony. The granular colony produced type-specific agglutinin, whereas the clear variety

was non-specific. It is not known whether this applies to all 30 strains.

(C) Preparation of Agglutinating Sera.

The method of preparing the agglutinating sera differs somewhat from that recommended by Griffith. (1934) (Journal of Hygiene 34: 542). The standard he aimed at was such that a tiny loopful of a 1 in 5 dilution of the serum which had been absorbed with a mixture of known heterologous strains to remove group agglutinins should give rapid flocculation with a drop of the homologous suspension on a slide.

The method here adopted was as follows:-

(a) To a drop on a slide of a heavy suspension of the type-specific haemolytic streptococcus was added a small loopful of the corresponding crude serum. If rapid agglutination did not occur, the serum was discarded and the responsible rabbit given a further course of injections. Trial bleedings showed when a sufficiently high titre in the serum had been reached. If after repeated trials the agglutinability of the serum remained low, fresh vaccine was prepared or a new rabbit injected.

(b) If, however, a marked agglutination took place on the slide the serum was regarded as suitable for further treatment.

(c) It was tested against the rest of Griffith's 30 strains and any cross-agglutination noted. This was done with all 30 sera.

Considerable cross-reaction was noted. (Vide Figure 2.)

(d) To a small test-tube containing 2 cc. of normal saline was added the serum, drop by drop. After the addition of each drop the agglutinating power of the saline-serum mixture was tried out. When this was found to be satisfactory (namely - when it rapidly agglutinated the organisms on the slide) the diluted serum was tried out with the other 29 organismal suspensions. In a number of cases it was found that cross-reaction no longer occurred and that therefore no absorption was necessary in those cases. (Vide Figure 3.) These types were:- 2, 6, 7, 8, 10, 13, 16, 18, 21, 27, 28, 30.

Since the titres of the various sera differed considerably, the number of drops added to the 2 cc. of saline varied correspondingly.

The titre seemed to bear little relation to the cross agglutination. For example:- In both antisera, types 8 and 22, five drops were added to the 2 cc. of saline. Both showed marked cross-agglutination before dilution, whereas after dilution cross reactions in type 8 were absent and in type 22 still marked.

This point was further investigated and it was found that the titre of both 8 and 22 was 1 : 640.

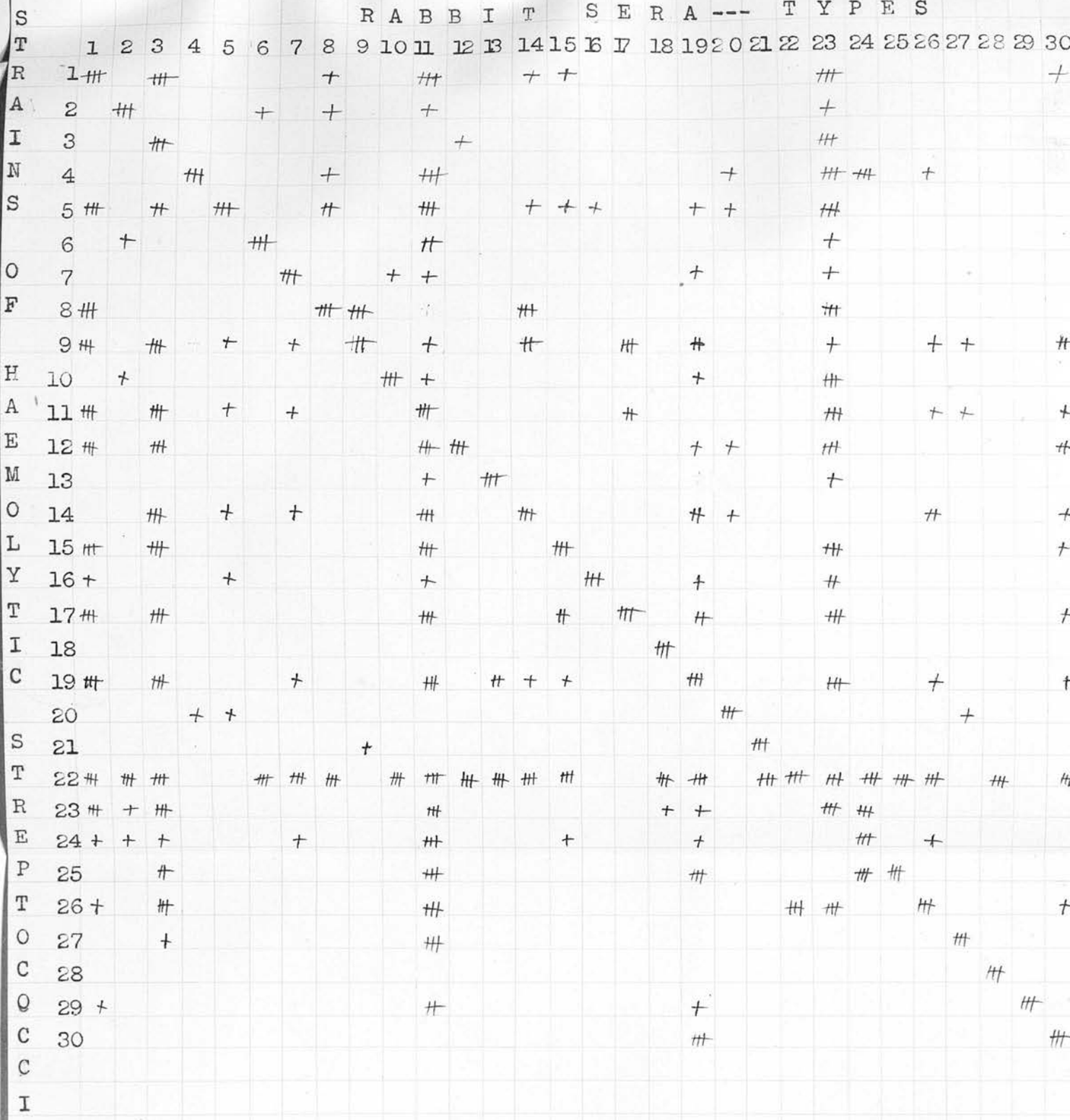

STRAINS OF RABBIT SERA --- TYPES
STRAINS OF HAEMOLYTIC STREPTOCOCCI
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

FIG. 2

RABBIT SERA --- TYPES

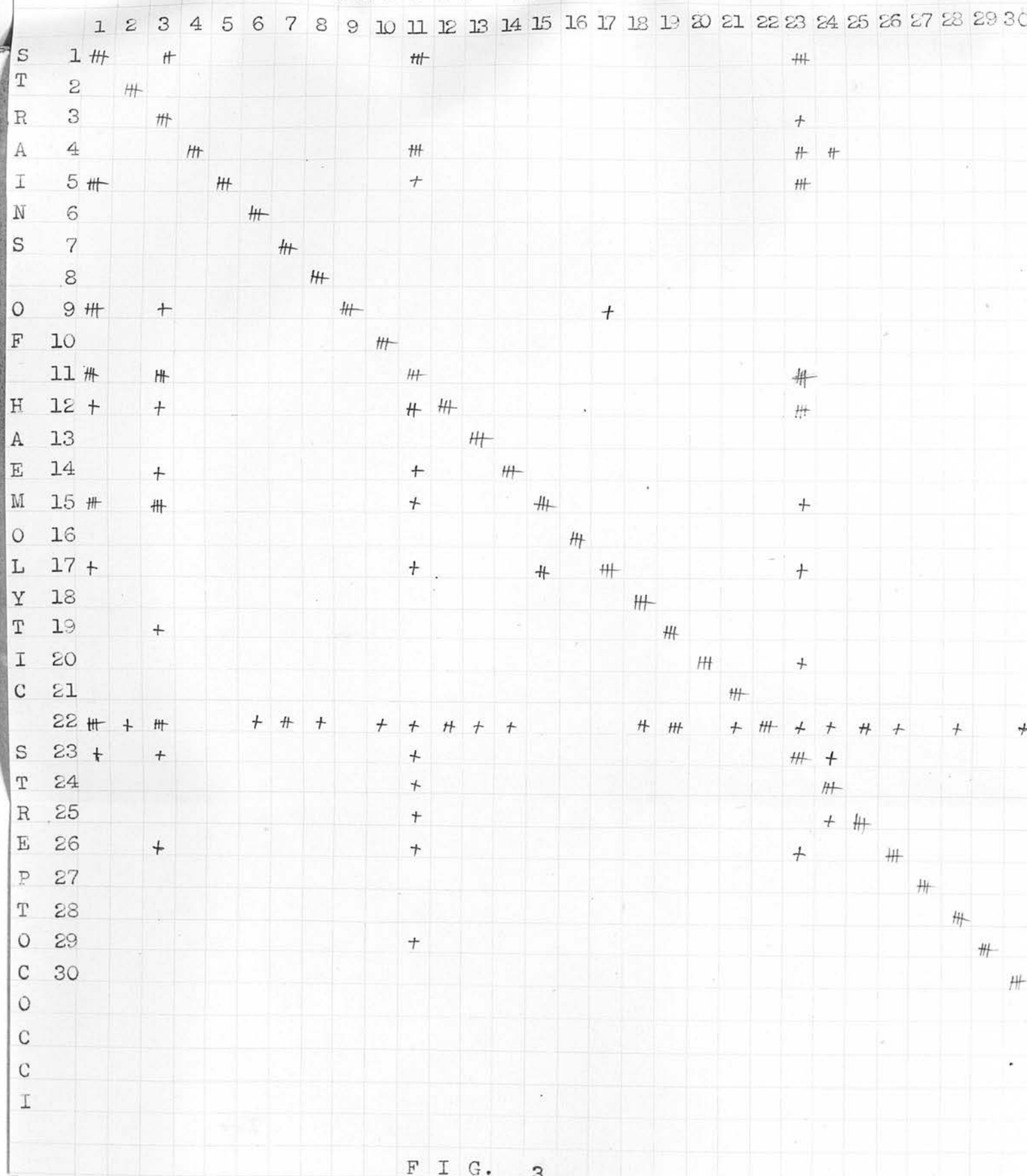


FIG. 3

The matter of the absence of cross-agglutination following the addition of saline, therefore, appears not to be the result of simple dilution.

(e) Absorption of heterologous Agglutinins.

From this point the preparation of type-specific antisera was similar to the simplified method advocated by Griffith.

A type 3 strain was grown on blood-agar to which had been added 10% of type 3 antiserum. Opaque and clear colonies were formed. A clear colony (non-specific) was transplanted into digest broth for 18 hours.

0.5 cc. of the crude serum, which gave cross reactions, was diluted 1 : 5 with saline and to it was added the deposit of 400 to 500 cc. of broth culture, type 3 (non-specific).

It was incubated in a water-bath at 37° C. for a few hours and then left at room temperature for 24 hours. Thereafter it was centrifuged and the supernatent serum again tested for type specificity. No group-agglutinins were detected except in types 11, 15, 17, and 19.

After a second absorption of these sera, in a similar manner, only type 17 serum was found to give a slight cross reaction with type 15 organism.

A third absorption did not remove this. In types 11 and 19, over-absorption had occurred with a marked

decrease of specific agglutinating power, and so fresh sera had to be absorbed.

(f) Pooling the Sera.

Pooled sera were prepared by mixing 0.5 cc. of each of five sera and adding to these the deposits of two litres of digest broth culture of non-specific type 3.

It must be observed that type 3 was absorbed by types 1, 2, 4, and 19, and in the pooled serum 1 to 5, type 3 serum was not added till after absorption, and then only as the absorbed serum.

P A R T II.

CLINICO-BACTERIOLOGICAL INVESTIGATION OF SCARLET CASES.

SECTION 1.

(A) Culture media for obtaining suitable growths of haemolytic Streptococci.

(i) A modification of Okell's digest-broth was used throughout the research. It gives heavy growths of streptococci, and was therefore particularly useful for the preparation of vaccines.

Okell's (modified) Digest for Streptococci:

1st day:-

2 lbs of horse flesh - minced. Add:-

1,500 cc. cold water and raise the temperature to 80° C. Add:-

2,000 cc. cold water and 12 gms. Sodium Carbonate (anhydrous).

Adjust pH to 8. Add 0.5% pancreatin, and place in an oven at 56° C. After 4 hours digestion, add:-

20 cc. of Hcl (concentrated).

Boil. Leave overnight.

2nd day:-

Filter through muslin.

To clear extract add:-

1% De Fresnes peptone,

0.125% $CaCl_2$,

0.2% $NaHCO_3$.

Steam till all the ingredients are dissolved

(about ¾ - 1 hour).

Raise the pH to 8.2.

Leave for ½ hour at this pH in the steamer.

Remove from the steamer and leave overnight.

A heavy deposit of phosphates occurs.

3rd day:-

Filter through Bernard Dumas filter paper.

Adjust the pH to 7.6 - 7.7.

Transfer the broth to screw-top bottles.

Sterilise in steam for 1¼ hours at 100° C.

(ii) Suspensions for agglutination tests.

The main difficulty in typing streptococci is to obtain suitable suspensions. A considerable number of the organisms tend to grow granular and thus form suspensions totally unsuitable for slide agglutination.

A series of experiments were carried out in an attempt to obtain homogeneous suspensions of the organisms:-

Veal broth was inoculated and incubated for 6-8 hours.

The same medium was inoculated and then incubated in a shaking-rack for 8, 12, and 24 hours.

The same medium with 1% agar was inoculated and incubated.

The same medium with 3% glycerine was inoculated and incubated.

The same medium with 1% gelatin was inoculated and incubated.

Ordinary trypsin broth was inoculated and incubated.

Horse-muscle digest-broth was inoculated and incubated.

Horse-muscle digest-broth with ascitic fluid was inoculated and incubated.

The same organisms were used in all the above experiments. (The same four strains for each medium.)

The best results were obtained by growing the organisms in horse-muscle digest-broth to which had been added 3% of ascitic fluid. The heaviest growths, but not the most homogeneous, were seen in the pure ascitic fluid.

A further series of experiments were carried out with the centrifuged granular deposits, with a view to rendering them homogeneous in some medium or other.

The deposits were put up in the following media:-

Saline.

Distilled water.

Alcoholic solutions.

Weak acid solutions (varying strengths).

Weak alkali solutions (varying strengths).

These were shaken up with and without beads.

A similar series to the above was incubated for 24 hours and then shaken.

In the majority of cases the final suspensions were still granular. The best results were obtained with distilled water incubated for 24 hours and then shaken.

None of the above methods proved very satisfactory. Although horse-muscle digest-broth with the addition of ascitic fluid was shown to be the best all round medium, it was observed that a number of granular growths in this broth gave "fine" suspensions when cultured in ordinary broth or ascitic fluid. It, therefore, appeared that the inherent growth characteristics of the haemolytic streptococci had also to be considered.

The method finally adopted for obtaining suspensions of the organisms, was as follows:-

(a) From a pure culture on a blood-agar plate, to a Wassermann tube half filled (3 cc.) with horse-muscle digest-broth, to which had been added 3% of ascitic fluid, some of the organisms were transferred.

(b) These were incubated for five hours and then observed. This was repeated at hourly intervals. The moment a tube showed slight clouding it was removed and left in a rack at room temperature for 12 to 24 hours.

(c) After this period the tubes were found to

contain an increase of growth. Those which showed a homogeneous suspension were ready for typing. The tubes with deposits and clear supernatent fluid were agitated in front of a light. A shot-silk appearance in the medium also indicated that they were suitable for typing. The other tubes were granular and had to be further treated.

(d) Each granular growth was plated out on blood-agar to see if a pure culture was being dealt with. It was also put up in the following three media:- horse-muscle digest-broth, the same medium with 6% rabbit serum added, and ascitic fluid. The procedure of incubation was the same as before.

By these means 93% of cultures gave "fine" suspensions.

The object of leaving the organisms at room temperature for 12 to 24 hours was because it appeared to increase the type-specificity. This must not be confused with the decrease of type-specificity which occurs when the organisms are incubated at 37°C. for 24 hours or longer

Of the 7% granular growths remaining no amount of subculturing in various media produced homogeneous suspensions. 11% of these growths were, however, made homogeneous by plunging a red-hot loop into the centrifuged deposit of organisms. In some cases this had to be repeated a number of times. It was, however,

found that in these cases where agglutination occurred it was markedly delayed and not complete.

(B) Slide-agglutination Method of Typing.

The slide-agglutination of typing the haemolytic streptococci devised by Dr. Griffith, and used throughout this work is as follows:-

(i) Suitable suspensions of organisms are centrifuged.

(ii) With a rubber teat and Pasteur pipette most of the clear broth is drawn off and the organismal deposit agitated into a thick homogeneous suspension.

(iii) Six drops of this is placed on a slide and observed under a low-power binocular microscope to verify their homogeneity. Direct illumination is better than transmitted light from a substage.

(iv) With a small loop of thin platinum wire a little of the pooled serum A (1-5) is added to the first drop. It is slowly mixed with the organisms and its effect observed under the miscrscope. If no agglutination occurs, the loop is flamed and serum B (6-10) is tried; and so on up to serum F (25-30), if necessary.

(v) If no agglutination occurs, the slide is gently moved in a circular, undulating manner. This frequently shows some slight agglutination missed by the ordinary method.

(vi) If agglutination occurs, the five type-specific sera corresponding to the agglutinating pooled

serum are tried out on the five unaffected drops on the slide.

A strongly positive agglutination (+++) is indicated by a clumping of the organisms within a few seconds. The clumps are large, coarse, irregular and tend to collect on the periphery of the drop. Average agglutination (++) is indicated by a slower reaction (10-15 seconds), the clumps are smaller and more evenly dispersed throughout the drop. When agglutination is poor (+), there is marked delay in reaction - often for a minute or more and there is no definite clumping. It is only by comparison with the other drops on the slide that it becomes evident that slight agglutination has occurred.

(C) Procedure of Swabbing scarlet fever cases and typing the organisms.

All cases of scarlet fever were swabbed as soon after entry into the hospital as possible. Fortunately night-admissions in the City Fever Hospital are rare, and so most of the swabs were obtained within a few hours of the patient's entering the wards.

The following was the routine procedure adopted in most cases:-

(i) On entry, two swabs were taken - throat and nasal. In those cases which were admitted with complications (e.g. otorrhoea, sepsis, etc.) a third

swab was taken, if discharges were present.

(ii) All cases were kept under observation from day to day and when complications occurred swabs were taken as above.

When swabbing throats, an attempt was made to get as far back into the fauces as possible. Before withdrawing the swabs both tonsils were rubbed. With nasal swabs thinner pledgets of cotton-wool on the ends of the swab sticks gave better results, for they could be inserted deeper into the nares.

(iii) All swabs were plated out on blood-agar plates for 16 to 18 hours. This was found to be the optimum time to give the best discreet colonies.

Colonies were then picked off and subcultured on blood-agar plates. These were incubated for 12 to 14 hours.

(iv) When typing was to be undertaken, the procedure from this point was that described under "suspensions for agglutination tests".

(v) Early in the work, when it was necessary to store the types while specific antiserum was being prepared, subcultures were made into small tubes of broth containing a little minced meat. These were incubated for 18 hours and then stored in the refrigerator pending typing.

(D) Storing Haemolytic Streptococci in vacuo.

At this point it may be appropriate to indicate the method employed when it was necessary to store the organisms for a long period of time.

Flocculation-tubes were drawn out into a fine constriction near the open end. They were then sterilised.

A few drops of a young culture of organisms were put into each tube (labelled) by means of a Pasteur pipette. The tubes were then placed into the refrigerator. Thereafter they were dried in a dessicator with phosphorous pentoxide and under vacuum. This usually took 12 to 18 hours. The tubes were removed from the dessicator. Each one, in turn, was attached by a thick rubber tube to a vacuum pump, and air exhausted. While the pump was still working the tube was sealed at the constriction over a flame.

By storing the tubes in the refrigerator the organisms could be kept alive for periods well over a year.

SECTION 2.

Streptococci in Scarlet Fever Cases in the City Fever Hospital.

(A) Statistics.

Date.	Total Entries.	Total number swabbed.	Total Complications.	Total Complications swabbed.
1937.				
Sept.	177	177	34	34
Oct.	254	254	63	63
Nov.	248	248	73	73
Dec.	217	217	65	65
1938.				
Jan.	160	160	48	48
Feb.	142	142	57	57
March	133	133	45	45
April	111	20	32	--
May	131	20	52	--
June	101	101	29	29
July	83	20	21	--
Aug.	78	20	24	--
Sept.	94	94	24	24
Oct.	89	89	19	19
Nov.	76	76	14	14
Dec.	75	20	--	--
1939.				
Jan.	--	20	--	--
Feb.	--	20	--	--
Totals	2169	1831	600	471

Excluding the months April, May, July, August,

December of 1938, and January and February of 1939, during which only a few isolated cases were swabbed, all entries and all complications were investigated. They were as follows:-

Total Number of Admissions swabbed.		Total Number of Complications swabbed.
1/9/37 - 30/11/37 ...	679.	170
1/12/37 - 31/3/38 ...	652	215
1/6/38 - 30/6/38 ...	101	29
1/9/38 - 30/11/38 ...	259	57
Total	1,691	471

Figures 4 and 5 are monthly tables showing Age and Sex of scarlet fever patients.

Figure 6 is a monthly table showing complications of scarlet fever patients.

Tables of Streptococcal Types in Scarlet Fever.

(a) From September 1st. 1937 to November 30th 1937, of the 679 cases swabbed, 659 (95%) gave positive haemolytic streptococci swabs. Of these, 79 had become sterile from storage. The 580 positive cultures, which represented the organisms found in the patients on admission, were grouped as follows:-

F E M A L E S.

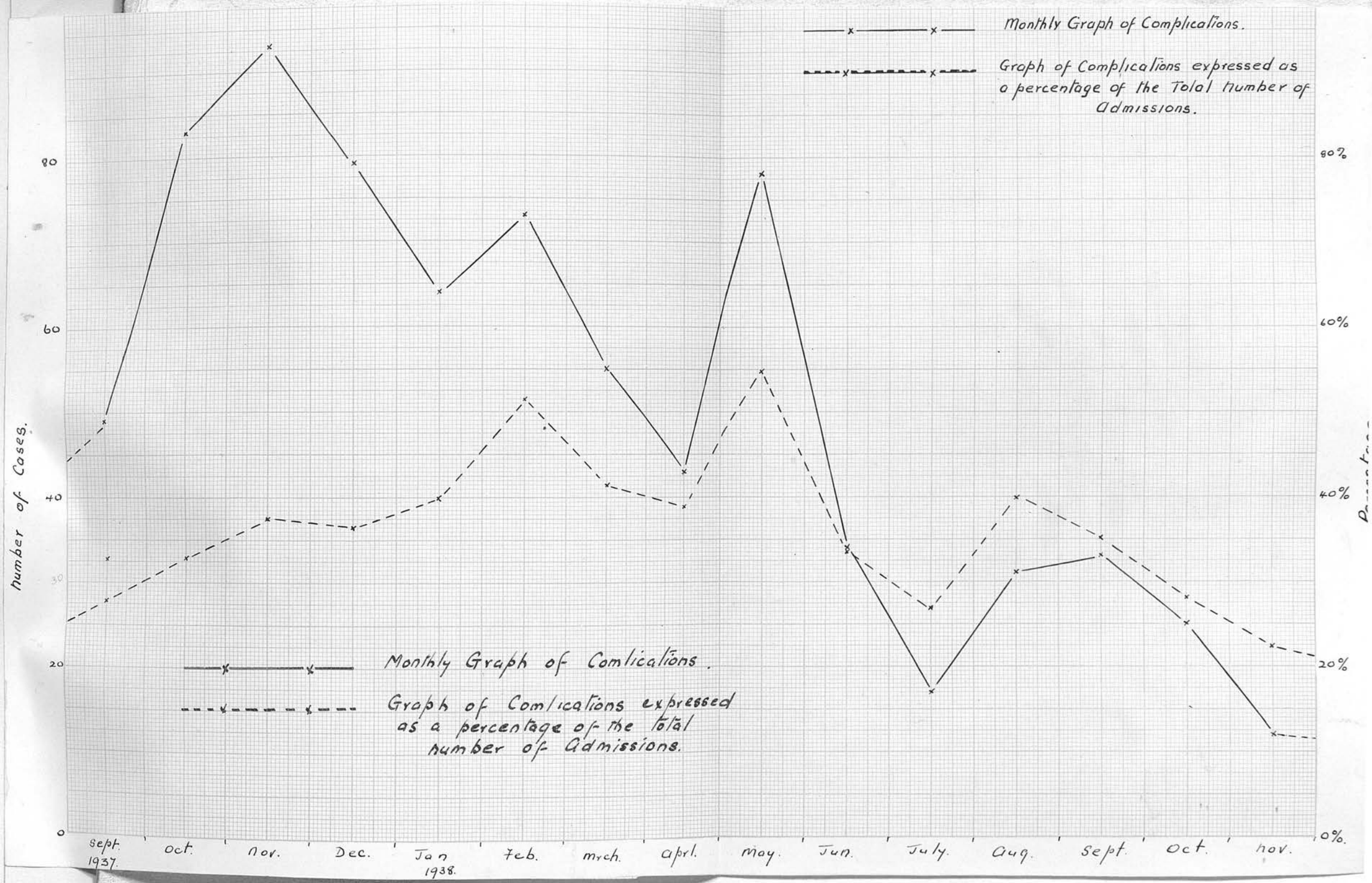
	0-1	1+	2+	3+	4+	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60+	Total.
1937.														
Sept.	0	0	2	11	11	50	15	3	2	4	0	0	0	98
Oct.	2	6	10	12	7	67	27	10	4	3	0	0	0	148
Nov.	0	5	8	8	7	64	28	12	13	0	0	2	0	147
Dec.	0	4	5	7	9	36	26	10	9	6	2	1	0	115
1938.														
Jan.	0	4	2	4	6	29	14	14	9	5	0	2	0	89
Feb.	1	1	2	7	3	26	7	7	6	2	4	0	0	66
Mch.	0	2	2	8	9	32	13	7	4	3	0	0	1	81
Apr.	0	1	3	7	3	21	14	10	7	2	0	0	0	68
May	2	2	5	7	5	30	11	11	7	1	1	0	0	82
June	0	2	3	6	3	21	9	4	3	1	0	1	1	54
July	0	0	5	1	6	23	6	5	5	2	0	0	0	53
Aug.	0	3	6	5	2	16	7	4	1	1	0	0	0	45
Sep.	0	2	4	3	3	30	10	3	1	0	0	0	0	56
Oct.	1	3	0	5	4	22	8	5	1	0	1	0	0	50
Nov.	1	1	3	3	3	22	5	1	5	0	0	1	0	45
Dec.	0	2	4	3	4	10	4	4	7	1	2	0	0	41
	7	38	64	97	85	499	204	110	84	31	10	7	2	1238

FIG. 4

M A L E S.

	0-1	1+	2+	3+	4+	5-9	10-14	15-19	20-29	30-39	40-49	50-59	60+	Total.
1937.														
Sept.	0	7	6	8	9	38	8	1	0	2	0	0	0	79
Oct.	1	1	9	14	11	46	15	3	0	4	1	1	0	106
Nov.	1	6	5	5	8	40	24	6	6	0	0	0	0	101
Dec.	0	6	6	8	7	41	20	4	6	4	0	0	0	102
1938.														
Jan.	0	2	3	8	1	32	14	3	3	2	2	1	0	71
Feb.	1	5	8	4	9	21	12	6	7	1	1	1	0	76
Mch.	0	2	4	5	5	22	5	4	5	0	0	0	0	52
Apr.	0	3	3	3	2	19	4	3	3	2	1	0	0	43
May	1	3	3	6	4	23	4	3	0	0	0	1	1	49
June	0	0	4	5	4	19	8	1	2	1	2	1	0	47
July	0	1	0	2	2	20	3	0	2	0	0	0	0	30
Aug.	0	2	5	1	1	18	4	0	1	0	1	0	0	33
Sept.	0	2	7	0	2	22	3	0	1	1	0	0	0	38
Oct.	1	2	3	3	5	17	7	0	0	1	0	0	0	39
Nov.	0	1	2	2	5	17	3	1	0	0	0	0	0	31
Dec.	0	2	1	1	1	15	6	1	3	4	0	0	0	34
	5	45	69	75	76	410	140	36	39	22	8	5	1	931

FIG. 5


Monthly Graph of Complications.
Graph of Complications expressed as a percentage of the Total number of Admissions.
Number of Cases.
Percentage
0
20
40
60
80
0%
20%
40%
60%
80%
Sept. 1937.
Oct.
Nov.
Dec.
Jan 1938.
Feb.
March.
April.
May.
Jun.
July.
Aug.
Sept.
Oct.
Nov.
Monthly Graph of Complications.
Graph of Complications expressed as a percentage of the total number of Admissions.

Type	1	.....	316 cases
"	2	.....	42 "
"	3	.....	10 "
"	4	.....	28 "
"	6	.....	4 "
"	8	.....	19 "
"	11	.....	9 "
"	15	.....	13 "
"	22	.....	4 "
"	23	.....	2 "
"	25	.....	6 "
"	27	.....	6 "
"	28	.....	3 "
Untyped		.....	118 "

Percentage typed 79.7

(b) From December 1st, 1937 to March 31st, 1938, of the 652 cases swabbed 629 (96.5%) gave positive haemolytic streptococci swabs. These were typed as follows:-

Type	1	.....	371 cases
"	2	.....	61 "
"	3	.....	45 "
"	4	.....	20 "
"	6	.....	2 "
"	8	.....	10 "

Type 11 .... 5 cases

" 27 .... 2 "

Untyped .... 113 "

Percentage typed 82

(c) From June 1st to June 30th, 1938, of the 101 cases swabbed, 97 (96.1%) gave positive haemolytic streptococci swabs. These were typed as follows:-

Type 1 .... 39 cases

" 2 .... 20 "

" 3 .... 1 case

" 4 .... 16 cases

" 11 .... 1 case

" 25 .... 2 cases

" 28 .... 1 case

Untyped .... 16 cases

Percentage typed 83.5

(d) From September 1st 1938 to November 30th, 1938 of the 259 cases swabbed, 248 (95.8%) gave positive haemolytic streptococci swabs. These were typed as follows:-

Type 1 .... 60 cases

" 2 .... 11 "

" 4 .... 110 "

" 6 .... 14 "

" 18 .... 9 "

Untyped .... 44 "

Percentage typed ... 81.9

Complications.

Corresponding to the time periods, just mentioned, the total number of complications which occurred was 471.

30 of these gave no haemolytic streptococci culture. On analysis these proved to be:-

4 .. B.coli (almost pure culture)

7 .. St. aureus (6 almost pure culture)

5 .. S. viridans, (almost pure culture).

14 .. Mixed growths (showing pneumococci S. viridans, etc.)

The 441 cases which yielded haemolytic streptococci are divided into the following three classes:-

82 cases ... same types as were present on admission.

296 " ... new types present.

63 " ... could not be typed.

Percentage of cases showing haemolytic streptococci typed ... 85.7

Figure 7 is a table showing the various types of haemolytic streptococci found in the scarlet fever cases examined in the City Fever Hospital. The numbers 154 for September 1937, 215 for October, 211 for November, etc., do not include those cases swabbed, which gave a negative haemolytic streptococcal finding. The numbers of cases which could not be typed are enumerated at the foot of the table.

MONTHLY TABLE showing Types of HAEMOLYTIC STREPTOCOCCI found in Scarlet Fever Cases.

Total Number of cases swabbed showing H.S. +	1937. Sep.	Oct.	Nov.	Dec.	1938. Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	1939. Jan.
	154	215	211	209	154	137	129	20	20	96	20	20	89	85	74	20	20
Types: 1	47	126	143	107	98	90	76	13	11	39	7	5	32	18	10	2	2
2	10	13	19	19	13	13	16	1	2	20	2	1	6	4	1	1	0
3	1	4	5	15	10	8	12	0	0	1	1	0	0	0	0	0	0
4	19	7	2	16	3	1	0	1	1	16	5	8	27	40	43	13	12
6	3	1	0	2	0	0	0	0	0	0	0	0	3	7	4	1	0
8	10	6	3	7	2	1	0	0	0	0	0	0	2	3	4	0	0
11	5	4	0	4	0	1	0	0	1	1	0	0	0	0	0	0	0
15	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
22	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	2	3	1	0	0	0	0	1	2	3	1	2	0	0	0	0	0
27	2	3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
28	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Untyped	43	41	34	38	28	22	25	4	2	16	4	4	19	13	12	2	5

FIG. 7

In Figure 8 the above numbers have been converted into percentages. This has been done in order to appreciate better the monthly increase or decrease of the various types relative to one another. These percentages are represented graphically in Figures 9 and 10. The first graph only embodies the types 1, 2, 3, 4, 6, 8 and 11. The addition of the other types would so complicate the reading of the chart at the foot as to render it unintelligible. The second graph is on a scale ten times that of the first.

It will be observed that from September 1937 to July 1938 type 1 was definitely the predominant epidemiological strain. From May 1938 to the end of December there was a steady increase of type 4, whilst type 1 dropped correspondingly.

There appears to be some epidemiological factor which accounted for the relative increase or decrease of these two types. During September, October and November 1937 there was an increase of type 1 and a decrease of type 4. In December this state was reversed. From May 1938 to December the two types were graphically the converse of each other.

A striking fact is the sudden increase in type 2 during June 1938, for the rest of this type appears fairly uniform in its occurrence. (Varying between 5 and 10% of the total number of cases.)

The other types are mostly sporadic outbursts. This will be seen in the second graph.

MONTHLY CHART showing Percentage of Types of

HAEMOLYTIC STREPTOCOCCI found in Scarlet Fever Cases.

	1937. Sept.	Oct.	Nov.	Dec.	1938 Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	1939 Jan.
Types: 1	30.5	58.5	67.8	51.4	63.6	65.7	58.9	65	55	40.2	35	25	35.9	21.2	13.5	10.0	10.0
2	6.5	6.0	9.0	9.1	8.5	9.5	12.4	5.0	10.0	20.6	10.0	5.0	6.7	4.7	1.4	5.0	--
3	0.6	1.9	2.4	7.2	6.5	5.9	9.3	--	--	1.0	5.0	--	--	--	--	--	--
4	12.3	3.1	.9	7.6	1.9	0.9	--	5.0	5.0	16.5	25.0	40.0	30.3	47.1	58.1	65	60
6	1.9	0.4	--	0.9	--	--	--	--	--	--	--	--	3.4	8.2	5.5	5.0	--
8	6.5	2.8	1.4	3.3	1.3	0.9	--	--	--	--	--	--	2.2	3.5	5.5	--	--
11	3.2	1.9	--	1.9	--	0.9	--	--	0.5	1.0	--	--	--	--	--	--	--
15	5.3	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	5.0
22	1.9	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
23	--	--	0.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25	1.3	1.4	0.5	--	--	--	--	5.0	10.0	3.1	5.0	10.0	--	--	--	--	--
27	1.3	1.4	0.5	0.5	--	0.9	--	--	--	--	--	--	--	--	--	--	--
28	0.6	0.4	0.5	--	--	--	--	--	5.0	--	--	--	--	--	--	--	--
Percentage Untyped:	27.9	19.1	16.6	18.2	18.2	16.0	19.4	20.0	10.0	16.5	20.0	20.0	21.3	15.3	16.2	10.0	25.0

FIG. 8

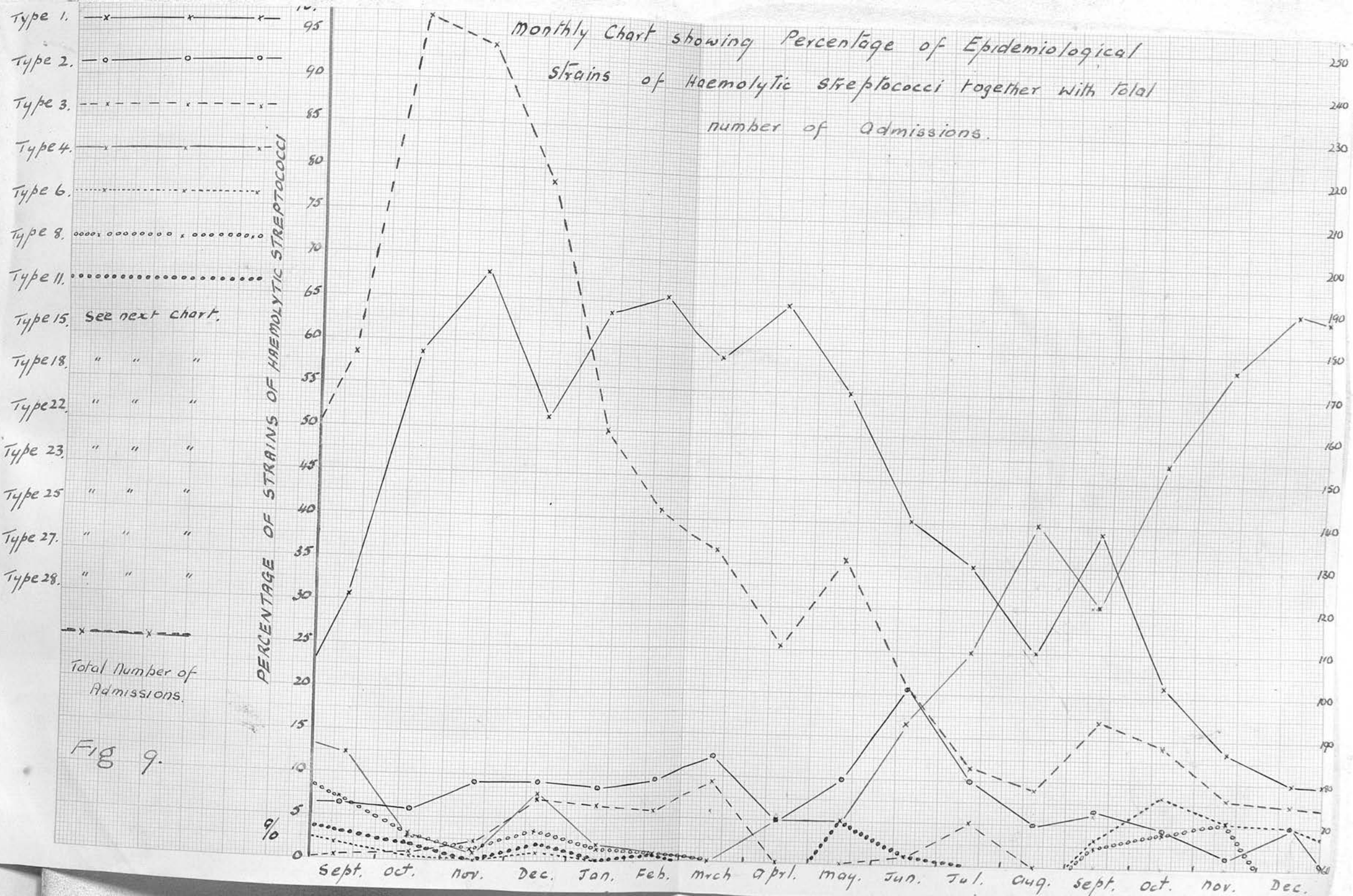

Monthly Chart showing Percentage of Epidemiological Strains of Haemolytic Streptococci together with total number of Admissions.
Type 1.
Type 2.
Type 3.
Type 4.
Type 6.
Type 8.
Type 11.
Type 15. See next chart.
Type 18. " " "
Type 22. " " "
Type 23. " " "
Type 25 " " "
Type 27. " " "
Type 28. " " "
Total Number of Admissions.
PERCENTAGE OF STRAINS OF HAEMOLYTIC STREPTOCOCCI
%
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Sept. Oct. Nov. Dec. Jan. Feb. Mrch Aprl. May. Jun. Jul. Aug. Sept. Oct. Nov. Dec.

Fig 9.

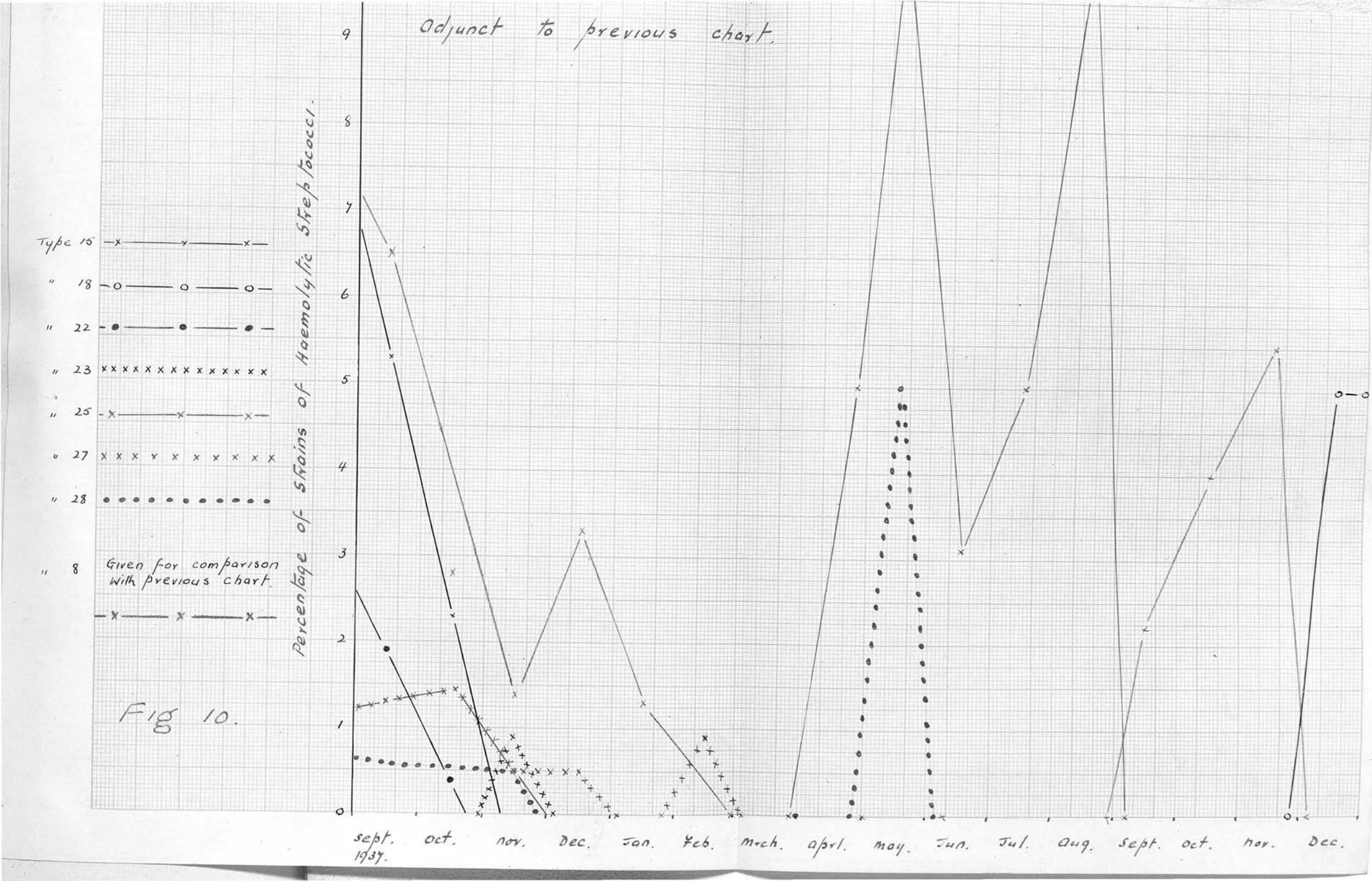

Adjunct to previous chart.
Percentage of Strains of Haemolytic Streptococci.
0
1
2
3
4
5
6
7
8
9
Type 15
" 18
" 22
" 23
" 25
" 27
" 28
" 8
Given for comparison with previous chart.
sept. 1937.
oct.
nov.
Dec.
Jan.
Feb.
March.
April.
May.
Jun.
Jul.
Aug.
Sept.
oct.
nov.
Dec.

Fig 10.

During each of the months April, May, July, August and December, 1938, and January 1939, only 20 cases were swabbed. This was done with a view to keeping in contact with the epidemiological strains.

Summary of Figures.

1st September 1937 to 31st December 1938.

Number of Scarlet Fever admissions 2169.

Total number of Complications 779 (35.9%)
(Including more than one complication in certain cases.)

Number of cases showing complications 600 (27.7%)

Number of Scarlet Fever cases swabbed (including Jan. and Feb. 1939) 1831

Number of cases with complications swabbed 471

Total number of cases showing positive haemolytic streptococci swabs 1664. (96.6%)

of the total number of cases swabbed.

(There appears to be an error here when considering this percentage. It must, however, be remembered that a number of cultures became sterile from storage early in this research. These have been added to the number 1664.)

Number of strains out of a total of 1664 swabs was 1352, i.e. 81.3%.

Of the 2169 cases of Scarlet Fever - 1253 cases were between the ages of 5 and 14 and of these 909 occurred during the first five years of school.

(B) Details of Investigation of Scarlet Fever Cases.

I N V E S T I G A T I O N I.

In this investigation the throats and noses of all admissions were swabbed. The object of this dual procedure was to ascertain whether any differences were to be found in the swabs so taken.

From 25/10/37 to 18/12/37 415 cases of Scarlet Fever were swabbed.

Swabs were taken in all cases within a few hours of the patients' entering the wards. If a case had been in hospital for more than four hours it was regarded as unsuitable. This precaution was exercised to prevent false readings which may have resulted from the inhalation of haemolytic streptococci present in the air.

The results obtained were as follows:-

(1) Of the 415 cases swabbed, 366 had haemolytic streptococci either in the throat or the nose. This gives only 88.2% of the positives. All negative cases were swabbed a second time (the following day), which increased the positive swabs by 35 and brought the percentage up to 96.6. These cases were, however, not included in the investigation.

Only the 366 cases are therefore under consideration.

(2) In 115 cases both the nose and the throat gave positive swabs. It may be generally stated that

the throat swabs gave better growths than those from the nose.

(3) In nine cases the nasal swab was positive, whereas the throat showed no haemolytic streptococci. This represents 2.5%.

(4) 242 nasal swabs were negative.

(5) Total number of throat swabs positive .. 357

" " " nasal " " .. 124

(6) Typing of strains: (I was fortunate in obtaining from Dr Griffith on 25/10/38 a small amount of each of his thirty type-specific antisera. With this I was able to carry out the work until I had prepared my own antisera.)

The 366 strains were divided as follows:-

Type	1	241
"	2	30
"	3	7
"	4	5
"	8	8
"	11	4
"	15	5
"	25	4
Untyped:	....	62
Total ..		366

It was found that of the 230 strains isolated from both nose (115) and throat (115), there were only two differences of type:-

	Throat	Nose
Type	2	untyped
Types	1	11

On analysing these figures it is seen that the untyped nasal strain may or may not have represented type 2. In the other case there is the perplexing problem of which is the disease-producing organism. Both strains have been found to account for Scarlet Fever.

Basing the conclusion on the one definite case of difference, it may be stated that in 99 per cent or more of Scarlet Fever cases the haemolytic streptococci in the nose and throat are of the same type.

This fact was accepted and from 20/12/37 only throat swabs were taken. The possible error thus introduced in the typing of case strains may have to be considered, but it is very slight. The amount of time spent in taking two swabs and typing the organisms, did not justify a continuance of this method of investigation.

I N V E S T I G A T I O N II

In this investigation an attempt was made to determine whether there occurred more than one type of haemolytic streptococcus in the throat swabs of patients.

Experiment (1)

12 cases of scarlet fever were swabbed as soon after admission as possible. Eight of the best plates were chosen and six of the most varied haemolytic streptococcal colonies picked off each plate. The same types for individual cases occurred throughout:-

25/12/37.

Patient.	Types of haemolytic streptococci.						
Colonies	1.	2.	3.	4.	5.	6.	
Lockhart Urquhart	1	1	1	1	1	1	
Richard Horsburgh	1	1	1	1	1	1	
Patricia Irvine	8	8	8	8	8	8	
Cathie Steele	1	1	1	1	1	1	
Jean Smiles	?	?	?	?	?	?	(untyped)
John McDermid	2	2	2	2	2	2	
Edwin Wilson	3	3	3	3	3	3	
John McMahon	1	1	1	1	1	1	

Experiment (2).

2/11/37.

A throat swab was taken of Nurse E. Nicholas,

who was in a room by herself. The blood plate was particularly interesting since it showed an almost pure culture of haemolytic streptococci, with differences in their colonial appearances. Some appeared moist and opaque with a large zone of haemolysis round them, other were small, smooth and had only a narrow, clear zone of haemolysis. A third variety of colony seen had a rough umbilicated appearance, and the haemolytic area was poorly defined and irregular.

Three subcultures of each form of colony were made and later typed. All proved to be type 2.

Experiment (3)

5/11/37 to 7/11/37.

Nineteen cases were swabbed and as many colonies as appeared to differ were picked off each plate, subcultured and typed. The results were as follows:-

5/11/37.

Patient.	Types of haemolytic streptococci.										
Colonies:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11
George Brown	2	2	2	2	2	2					
Eliz. Foster ...	-	-	-	-	-	-	-	-	-	-	-
Margt. Currie ..	-	-	-	-	-	-	-	-			
Annie Muir	1	1	1	1	1	1	1	1	1	1	1
Helen Douglas ..	1	1	1	1	1	1	1	1	1	1	1
Cel. Law	1	1	1	1	1	1	1	1	1	1	1
Ina Ingles	23.	23.	23.	23.	23.	23					
Iris Brown	1	1	1	1	1	1	1	1	1	1	1
Annie Black	-	-	-	-							

6/11/37

Patient.	Types of haemolytic streptococci.										
Colonies:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11
Agnes Boa	1	1	1	1	1	1	1	1	1	1	1
Jack Hay	1	1	1								
Betty Young	2	2	2	2	2	2	2	2			
Jacq.Percival ...	1	1	1	1							
7/11/37.											
Edith Sharpley ..	4	4	4	4	4	4	4	4	4	4	4
Mary Butler	1	1	1	1							
Edith Leitch	-	-	-	-	-	-	-				
Thomas Scott ...	1	1	1	24	24	24	24	24	24	24	24
Dorothy Adam	3	3	3	3	3	3	3	3			
Alistain Crosby .	2	2									

Excluding the four cases in which the organisms could not be typed owing to the granularity of the suspensions, each case showed the same type in all the colonies, except one - that of Thomas Scott. This case yielded the two types 1 and 24.

Thomas Scott had entered hospital with a high temperature and had received 20 cc. of scarlet fever antitoxin. Thereafter he made an uneventful recovery. Four times, at weekly intervals, swabs were taken (7th, 14th, 31st, and 28th). On the 7th only type 1 was found. On the 14th both types were again present. On the 21st and 28th (before leaving hospital) only type 24 was present.

This "Sylvia Turton" (type 24) strain of Dr Griffith, also R23, Group I of Dr. A. F. Coburn, does not appear to be connected with scarlet fever. It has been found as a commensal in normal throats and in cases of sore throat in patients convalescent from rheumatic fever.

The fact that this strain was present when the patient left hospital, whereas type 1 was absent, appears to indicate that it normally inhabits the throat of that patient. This view is supported by the fact that no other cases of scarlet fever with that type have been observed in Edinburgh, nor did any cases, in hospital, develop any complications from it.

If we can exclude this case on the above grounds then the rest of this experiment points to the fact that it is highly probable that most cases of scarlet fever are individually due to only one type of haemolytic streptococcus.

The practice adopted after the completion of this experiment was to take only one swab, which was repeated twice if negative, and to pick off only one colony for typing purposes. This applied only to swabs taken on admission to hospital.

I N V E S T I G A T I O N III.

17/12/37.

This investigation was carried out with a view to ascertaining whether any cases, which had been in the wards for some time, carried more than one type of haemolytic streptococcus in their throats.

All the patients of Ward 2 were swabbed on 17/12/37, with positive results. Most of the patients had been in the hospital for over two weeks and therefore a considerable amount of cross infection must have occurred. The ward was particularly suitable for this investigation, for it went under quarantine the next day for chicken pox, and furthermore a high percentage of cases showed complications:-

Number.	Date of admission.	Name.	Age.	Complications.
1.	30/11/37	Patricia Miller	8	Late Adenitis.
2.	1/12/37	Eleanor O'Donnell	8	Do.
3.	"	Agnes Morrison	5	Otorrhoea.
4.	"	George Lawrie	6	Intercurrent Chicken Pox.
5.	2/12/37	Irene Lloyd	2½	
6.	"	Maria Goodfellow	3	
7.	3/12/37	Edith Bell	5	
8.	"	Robt. Watson	4	
9.	"	Arthur Hazel	8	Late Adenitis.
10.	"	Mitchell Kelly	3	Do.

No.	Date of admission.	Name.	Age.	Complications.
11.	4/12/37	Eleanor Munro	4	Otorrhoea & Adenitis
12.	"	Ian Dick	4½	Otitis media
13.	"	Pat. McFarlane	5	Adenitis
14.	5/12/37	Betty Quinn	1¼	Otitis media
15.	"	Norman Thatcher	5¾	Adenitis & Intercurrent Chickenpox.
16.	6/12/37	John Ireland	5	
17.	7/12/37	Stella Gardner	2	
18.	"	Margt. Ramsay	3	Rhinitis & Adenitis
19.	8/12/37	Jean Duncan	2	
20.	"	Barbara Duncan	3½	Intercurrent Chicken Pox.
21.	11/12/37	Reg. Spence	1	Do. do.
22.	14/12/37	Sheila Wilson	6	Do. do.
23.	15/12/37	Cath.Fairgrieve	2½	
24.	17/12/37	Isa Dudgeon	6	
25.	"	Mary Rae	17	

From each of the plates inoculated with the swabs of the above cases a number of colonies were picked off and subcultured. These varied from 1 to 15; according to the number of discreet colonies suitable for subculture. In those plates with an excess of 15 colonies, an attempt was made to select those which varied as much as possible. These were typed with the following results:-

No. of patient.	Type on Admission.	Number of Colony and Type of Haemolytic Streptococcus.														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	4	4	4	4	2	2	2	2	2	2	2	2	2	2	2
2	-	1	1	1	1	1	1	1	4	4	4	4	4			
3	27	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	4	4	4	4	4	4	4	4	4							
6	1	1	1	1	1	1	1	1	1	1	1	1				
7	1	1	1	1	1	8										
8	4	4	4	4	4	4	4	4	4							
9	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4
10	1	1	1	1	1	1	1	1	1	4	4	4	4			
11	1	1	1	4	4	4	4									
12	1	4	4	4	4	4	4	4	4	4						
13	8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	27	27	27	27	27	27	27	27	27						
15	1	27	27	27	27	27	1	1	1	1	1	1	1			
16	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	4	4	4	4	4	4	4	2	2	2	2				
19	4	1	1	1	8	8	4	4	4	4	4	4	4	4	4	4
20	2	2	2	2	2	2	2	2	2	2	2	2	2			
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	3	3	3	3	3	3	3	3	3	3	3					
23	1	1	1	1	1	4										
24	1	-	-	-	-	-	-	-	-	-	-	-	-			
25	6	6	6	6	6	6	6	6	6	6	6	6	6	6		

(A dash (-) indicates that the strain remained untyped.)

Summary:-

(1) In nine of the cases the original types alone were found.

(2) In ten of the cases the original types had disappeared altogether.

(3) In nine of the cases two types were found present.

(4) In one case three types were found.

On 29/12/37 the previous experiment was repeated with the following results:-

No. of patient	Type on admission.	Number of Colony and Type of Haemolytic Streptococcus.														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	2	2	2	2	2	2	2	2	2	2	2				
2	-	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	27	4	4	4	4	4	4	4	-	-	-					
4	1	No Haemolytic Streptococci present.														
5	4	Left Hospital 28/12/37.														
6	1	1	1	1	1	1	1	1	1	1	1	1				
7	1	Left Hospital 28/12/37.														
8	4	Do.														
9	2	4	4	4	4	4	4									
10	1	4	4	4	4											
11	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12	1	No haemolytic Streptococci present.														
13	8	1	1	1	1	1	1	4	4	4	4	4	4			
14	1	27	27	27	27	27	27	27	27	27	27	27				
15	1	27	27	27	27	27										
16	-	No haemolytic Streptococci present.														
17	1	4	4	4	4	4	4	4	4							
18	-	4	4	4	4	4	4	4								
19	4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
20	2	-	-	-	-	-	-	-	-	-	-	-	-			
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
23	1	4	4	4	4	4	4	4	4							
24	1	-	-	-	-	-	-	-	-	-						
25	6	6	6	6	6	6	6	6	6	6	6	6	6	6		

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On 7/1/38 the previous experiment was repeated with the following results:-

No. of patient	Type on Admission.	Number of Colony and Type of Haemolytic Streptococcus.
		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1	1	No Haemolytic Streptococci present.
2	-	4 4 4 4 27 27 27 27 27 27 27 27 27 27 27
3	27	- - - - - - - - - - - - -
4	1	No Haemolytic Streptococci present.
5	4	Left Hospital 28/12/37
6	1	Left Hospital 1/1/38.
7	1	Left Hospital 28/12/38.
8	4	Left Hospital 28/12/38.
9	2	4 4 4 4 4 4 4 4
10	1	4 4 4 4 4 4 4 4 4 4 4 4
11	1	No Haemolytic Streptococci present.
12	1	No Haemolytic Streptococci present.
13	8	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
14	1	27 27 27 27 27 1 1 1 1 1 1
15	1	27 27 27 27 27 27 27 27 27 27 27 27 27
16	-	1 1 1 1 1 1 1 1 1 1 1 1
17	1	4 4 4 4 4 4 4 (6?)
18	-	No Haemolytic Streptococci present.
19	4	8 8 8 8 8 27 27 27 27 27
20	2	27 27 27 27 - - - - - - - - -
21	-	No Haemolytic Streptococci present.
22	3	1 1 1 1 1 1 1 1 1 1 1 1 1
23	1	4 4 4 - -
24	1	1 - - - - - - - - - -
25	6	6 6 6 6 6 6 6 6 6 6

When the results of these three investigations are considered together the results are as follows:-

No. of patient.	Type on admission.	Types of Haemolytic Streptococci present on: 17/12/37	29/12/37	7/1/38.
1	1	4. 2.	2	NONE
2	-	1. 4.	4.	4. 27.
3	27	4.	4.	-
4	1	1.	NONE	NONE
5	4	4.	Discharged	
6	1	1.	1.	Discharged.
7	1	1. 8.	Discharged	
8	4	4.	Discharged	
9	2	2. 4.	4.	4.
10	1	1. 4.	4.	4.
11	1	1. 4.	4.	NONE
12	1	4.	NONE	NONE
13	8	1.	1. 4.	1.
14	1	27.	27.	27. 1
15	1	27. 1.	27.	27.
16	-	1	NONE	1.
17	1	-	4.	4. 6 (?)
18	-	4. 2.	4.	NONE.
19	4	1. 8. 4.	8.	8. 27.
20	2	2	-	27. -
21	-	-	-	NONE.
22	3	3.	1.	1.
23	1	1. 4.	4.	4.
24	1	-	-	1 -
25	6	6	6	6

It is evident that a considerable amount of cross infection occurred among the patients of this ward. The problem under consideration at that stage, however, was not cross infection, but to ascertain whether scarlet fever patients, already some time in the wards, harboured at any particular time, more than one strain of haemolytic streptococcus in their throats.

This investigation showed that this was the case.

In only six of the twenty five cases did the original type persist alone.

In no case were more than three types shown to exist in the throat at any particular time. It must, however, be recognised that, at the most, only fifteen colonies were taken from each plate and that a greater number might have shown an even greater number of types in single patients.

A point which appears to be of some interest is that once a new type occurs in the throat of a patient it tends to persist, either in conjunction with the original type or by replacing it. Where a third type occurs it is found to be either temporary in its presence or persists at the expense of the other types. A good example of this is seen in patient No.3. Here type 27 is replaced by type 4. Later 4 is associated with an unknown strain (-), which in turn replaces type 4.

From the above facts it appeared at first sight, that the future investigation of cross infection in scarlet fever wards, and of complications among the patients, would entail the additional labour of typing numerous colonies from each plate. The following research, however, showed that this was unnecessary.

I N V E S T I G A T I O N IV.

The object of this investigation was to ascertain whether the facts elicited in the previous experiment were applicable to cases the first day on which they presented complications.

Details:-

A number of cases were swabbed as soon as any clinical manifestations of complications were evident. The cases were divided into the following two categories:- (1) Those showing complications and accompanied by discharges. (2) Those showing complications unaccompanied by discharges.

(1) Complications with discharges:-

(a) June Wilson. Age 3½ years. Admitted 5/1/38.

Complication and Date: Vaginitis. 1/1/38.

On 30/1/38 there was a rise of the pulse rate to 114. The following day a slight vaginal discharge was observed. A swab was taken and a number of colonies were typed.

Type on Admission 1.

Colonies and Types of Haemolytic Streptotocci.

Date		1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12
31/1/38	Vagina:	4 4 4 4 4 4 4
	Throat:	4 4 4 4 4 4 4 4 4
4/2/38	Vagina:	4 4 4 4 4 4 4 4 4 4 4 4
	Throat:	No Streptococci present.

(b) Janet Kirkwood. Age 1 year. Admitted 5/1/38.

Complication and Date: Rhinitis. 22/1/38.

On the 22nd the temperature rose from an average of 97° F. to 98.4° F. and pulse rate to 120. Rhinitis was observed.

Type on Admission I.

		Colonies and Types.											
Date.	Swabs.	1	2	3	4	5	6	7	8	9	10	11	12
22/1/38	Nose:	4	4	4	4	4	4	4	4	4	4	4	4
	Throat:	4	4	4	4	4	4	4	4	4	4		
	Nose:	4	4	4	4	4	4	4	4				
	Throat:	4	4	4	4	4	4	4	4	4			
28/1/38	Nose:	4	4	4	4	4	1	1	1	1	1	1	1
	Throat:	4	4	1	1	1	1	1	1	1	1	1	1
2/2/38	Nose:	1	1	1	1	1	1	8	?	8	?		
	Throat:	1	1	1	1	1	1	1	1	1	1		
10/2/38	Nose:	1	1	1	1	1	1	1	8	8	8	8	8
	Throat:	1	1	1	1	1	1	1	1	1	1	8	8

(c) Eric Campbell. Age 2½ years. Admitted 13/1/38.

Complication and Date: Rhinitis. 4/2/38.

This patient had been circumcised at the Leith Hospital on 10/1/38. On 11/1/38 the rash appeared.

On admission a swab was taken from the penis and the throat.

Type on Admission: 2.

Date.		Colonies and Types.											
		1	2	3	4	5	6	7	8	9	10	11	12
13/1/38	Throat:	No haemolytic Streptococci present.											
	Penis:	2	2										
4/2/38	Throat:	4	4	4	4	4	4	4	4	4	4	4	4
	Nose:	4	4	4	4	4	4	4	4				
14/2/38	Throat:	4	4	4	4	4	4	4	4				
	Nose:	4	4	4	4	4	4	4	4				
23/2/38	Throat:	4	4	4	4	1	1	1	1	1	1	1	1
	Nose:	1	1	1	1	1	1	1	1				
23/3/38	Throat:	1	1	1	1	1	1	1	1	2	2		
	Nose:	1	1	1	1	1	1						
14/4/38	Throat:	2	2	2	2	2							
	Nose:	No haemolytic streptococci found.											

(d) Ian McInnes. Age 5½ years. Admitted: 16/1/38.

Complication and Date: Tonsillitis. 1/2/38.

Type on Admission: 1.

Date	Swabs.	Colonies and Types.											
		1	2	3	4	5	6	7	8	9	10	11	12
1/2/38	Throat:	25	25	25	25	25	25	25	25	25	25	25	25
2/2/38	"	25	25	25	25	25	25	25	1				
3/2/38	"	25	25	25	25	25	25	25	25	25	25		
5/2/38	"	25	25	25	25	25	25						
7/2/38	"	25	25	1	1	1	1	1	1	1	1	1	1
10/2/38	"	1	1	1	1	1	1	1	1				
11/2/38	"	1	1	1	1	1	1	1	1	1	25		

(e) Craigie Murray. Age 8 years. Admitted: 20/1/38.

Complication and Date: Otorrhoea (L). 22/1/38.
Mastoiditis (L). 1/2/38.
Otitis (R). 11/2/38.

Type on Admission: 2.

Date.	Swabs.	Colonies and Types.											
		1	2	3	4	5	6	7	8	9	10	11	12
22/1/38	Throat:	3	3	3	3	3	3	3	3	3	3	3	3
	Ear (L):	3	3	3	3	3	3	3	3	3	3	3	3
26/1/38	Throat:	3	3	3	3	3	3	3	3				
	Ear (L):	3	3	3	3	3	3	3	3	3	3	3	3
30/1/38	Throat:	3	3	3	3	3	1	1	1	1	1		
	Ear (L):	3	3	3	3	3	3	3	3	3	3	3	3
1/2/38	Throat:	1	1	1	1	1	1	1	1	3			
	Mastoid (L):	3	3	3	3	3	3	3	3	3	3	3	3
11/2/38	Throat:	8	8	8	8	8	8	8	8	8	8	8	8
	Ear (R):	8	8	8	8	8	8	8	8				
	Ear (L):	3	3	3	3	3	3	3	3	3	3	3	3
26/2/38	Throat:	4	4	4	4	4							
	Ear (R):	4	4	4	4	4	4	4	4	4	4	4	4
	Ear (L):	No Haemolytic Streptococci found.											
26/3/38	Throat:	1	1	1	1	1	4	4	4	4			
	Ear (R):	4	4	4	4								
	Ear (L):	No Haemolytic Streptococci found.											
26/4/38	Throat:	4	4	4	-	-	-	-					
	Ear (R):	4	4	4	4	4	4	4	4	4			
	Ear (L):	No Haemolytic Streptococci found.											

(2) Complications without Discharges:-

(a) Archibald Walker. Age 27 years. Admitted 6/1/38.

Complications and date: Arthritis. 17/1/38.

The patient entered hospital with rhinitis. The nasal swab gave the same type as the throat swab.

The temperature was normal by 13/1/38.

On 17/1/38 he complained of slight pains in back and neck. On 20/1/38 - polyarthritis and temperature 100.2.

Type on entry: 1.

Date.	Swabs.	Colonies and Types. 1	2	3	4	5	6	7	8	9	10	11	12
17/1/38	Throat:	1	1	3	3	3	3						
20/1/38	"	3	3	3	3	3	3	3	3	3	3	3	3
25/1/38	"	3	3	3	3	3	3	3	3	3			
10/2/38	"	2	2	2	2	2	2	2	3				

(b) Robert Clark. Age 9 years. Admitted 12/1/38.

Complication and date: Adenitis (L). 17/1/38.

Date.	Swabs.	Colonies and Types. 1	2	3	4	5	6	7	8	9	10	11	12
17/1/38	Throat:	2	2	2	2	2	2	2	2	2	2		
18/1/38	"	2	2	2	2	2	2	2	2	2	2	2	2
19/1/38	"	2	2	2	2	2							
20/1/38	"	2	2	2	2	2	2	2	2	8			
21/1/38	"	2	2	2	2	8	8	8	8	8	8	8	8
22/1/38	"	2	2	2	2	2	2	8	8				
23/1/38	"	2	2	8	8	8	8	8	8	8	8		
24/1/38	"	8	8	8	8	8	8	8	8	2	2		
25/1/38	"	8	8	8	8	8	8	8	8	8	8	8	

Date.	Swabs.	Colonies and Types.											
		1	2	3	4	5	6	7	8	9	10	11	12
26/1/38	Throat:	1	1	1	1	1	1	1	8	8			
27/1/38	"	1	1	2	2	2	2	2	2				
28/1/38	"	1	1	1	1	1	1	1	1	1	1	1	1
29/1/38	"	1	1	1	1	1	1	1					

It will be observed that in all the cases examined there was present in each case only one type of haemolytic streptococcus on the day the complication became manifest.*

The importance of this observation is evident. It points to the fact that the type of haemolytic streptococcus found in the discharge or throat is the causative type of the complication.

From this stage onwards only one colony was picked from each swab culture for typing. This considerably decreased the work.

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* In cases 1 (e) and 2 (a) this at first sight does not apply. Case 1 (e) showed two types on the 1/2/38 and 11/2/38 respectively (2 and 4). It will, however be observed that the individual swabs of the discharges showed only one type, viz: mastoid (L) - Type 2. Ear (R) - Type 4.

Case 2 (a) had arthritic pains on 17/1/38. On that day types 1 and 3 were present in the throat. The arthritis, however, at this stage was not accompanied by any temperature. This only occurred on 20/1/38 and on that day only Type 3 was found.

I N V E S T I G A T I O N V.

In this investigation a single ward was selected and daily swabs were taken of all the patients. This was done with a dual object: Firstly to ascertain how the introduction of new types of haemolytic streptococci behaved with regard to cross infection. Secondly, how long new types were found in the throats of the patients before they produced complications, if any.

Ward 3^a was selected for this purpose in the hope that a large number of types of haemolytic streptococci would be found there. This hope was based on the fact that a large proportion of the admissions are adults, including nurses. The following table shows the results of swabs taken daily from 1/2/38 to 23/2/38.

(See Table on next page.)

Table Showing Results of Daily Swabbings in Ward 3a.

Date — February.

Patient	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Joan Banks	8	8	8	8	8	D																	
2. Margt. Martin	1	0	0	0	0	0	1	D															
3. Ruby Ockrent	8	8	1	1	1	8	1	D															
4. Francis Donaghy	1	1	0	1	1	0	0	0	0	2	2	D											
5. Hilda Mathiesin	1	1	1	0	0	0	0	0	D														
6. Isa McLeod	1	1	1	8	8	1	1	0	D														
7. Janie Lamb	2	2	0	0	0	0	0	0	2	0	0	27	27	2	2	D							
8. Janet McLeod	3	3	3	3	1	3	3	1	1	1	1	1	D										
9. May Willison	4	4	2	2	1	2	2	1	1	2	1	1	1	1	0	0	0	0	D				
10. Beatrice Durkin	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
11. Jean Morrison	8	0	0	8	1	2	1	1	2	1	1	—	—	0	1	1	2	1	1	D			
12. Dorott. Dunbar	4	4	4	4	4	0	0	0	27	27	27	27	27	27	27	D							
13. Wilhelm. Dewer	0	—	—	—	—	—	0	0	—	—	27	0	0	27	1	1	1	0	0	D			
14. Janet Murray	1	1	1	1	0	0	1	1	0	27	0	27	27	1	1	0	0	0	0	D			
15. Margt. Henderson	2	2	2	2	0	0	0	8?	0	0	0	27	0	0	0	0	0	0	0	D			
16. Mary Robertson	0	0	0	—	—	1	1	1	1	1	27	—	0	0	0	0	27	0	0	D	0	1	D
17. Agnes Kinnoch	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D
18. May O'Rourke	3	3	3	3	3	0	0	3	0	0	0	27	27	27	27	0	0	0	27	1	1	1	1
19. Rachael Hutton	4	4	4	4	4	4	4	4	0	4	0	4	4	4	0	0	0	4	4	4	4	4	4
20. Minnie Caseby				8	8	8	8	8	8	1	1	1	0	0	0	1	1	0	1	0	0	0	0
21. Wilhelm. Petrie							27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	0	0
22. Agnes Thomson								1	0	0	1	0	0	0	0	1	4	4	4	0	4	4	4
23. Edith Ross								1	1	1	1	0	1	0	0	1	1	1	27	27	1	1	1
24. Mary Kidd									4	4	4	0	4	0	4	0	0	0	0	0	27	27	0
25. Marion Blair										3	3	3	1	1	1	1	0	0	0	1	0	27	0
26. Hilda Foster										1	1	1	1	1	1	0	8	1	1	8	8	1	0
27. Mgt. Keyes										0	0	1	0	0	27	0	0	0	1	0	0	27	0
28. Jean Heriot													1	1	1	1	1	1	0	1	0	27	0
29. Mary Henderson																						2	2
30. Eliz. McCallum																						1	1
31. Marj. Caird																						4	4
32. Barbara Blythe																							11
33. Agnes Mackay																							—
34. Agnes Wilson																							1
35. Mgt. Murtrie																							
36. Eliz. Morgan																							

Present in Ward on 30/1/38.

— = The strain could not be typed.
0 = Throat swab negative
D = Discharged from Hospital
4 = Type present on the day the complication occurred.

	Patient.	Age	Admitted.	Type on Admission.	Complications after 1/3/38.
1.	James Massie	1½	4/2/38	1	
2.	Rod.McCuaig	4½	5/2/38	1	
3.	Alex. Adam	3	5/2/38	3	
4.	John Boulton	2½	9/2/38	-	
5.	Cecil Graham	4	10/2/38	1	Dysentry (Sonne) 7/3/38
6.	Rodger McClean	3½	11/2/38	2	Rhinitis 11/3/38
7.	John Bee	2	12/2/38	Negative swab.	
8.	Marg.Murdoch	3½	14/2/38	1	
9.	Morag McCuaig	1	14/2/38	1	Adenitis 3/3/38
10.	Murdo McPherson	4	15/2/38	1	
11.	Jo.Sutherland	1	16/2/38	1	Rhinitis 3/3/38
12.	Cath.Simpson	2	16/2/38	1	
13.	Wm. Crooks	2	17/2"38	-	
14.	Eliz. Gough	3	19/2/38	4	
15.	Martin Loy	2	19/2/38	1	Nephritis 11/3/38; Adenitis 13/3/38; Died 28/3/38.
16.	Marl.Thomson	2½	19/2/38	1	
17.	David Bailey	4¾	21/2/38	-	Dysentry (Sonne) 23/3/38
18.	John Thornton	2½	20/2/38	-	
19.	Mgt. Conie	3½	21/2/38	1	
20.	Sheila McLeod	4	21/2/38	1	
21.	Norman Ramage	2	22/2/38	3	Nephritis 23/3/38; Adenitis 25/3/38.
22.	Elspeth Leitch	4	23/2/38	-	Nephritis 3/3/38.
23.	John Hart	1	25/2/38	1	Relapse 22/3/38; Rhinitis 30/3/38.
24.	James Stewart	2½	25/2/38	4	Pyrexia 2/3/38.
25.	Bruce Young	2½	25/2/38	1	
26.	Jas. McVicar	1¾	26/2/38	Negative Swab.	Rhinitis 14/3/38
27.	Ken. Young	4	28/2/38	1	
28.	Sydney Rhind	4	28/2/38	1	Adenitis 12/3/38.

The following cases entered the ward after 1/3/38.

	Patient.	Age.	Admitted.	Complications.
29	Agnes Watson	3	2/3/38	Rhinitis 25/3/38
30	Isa. Clark	3	2/3/38	
31.	Wm. Stewart	4	2/3/38	
32.	Cath. Ross	3½	3/3/38	Multiple furunculosis 10/3/38 - 14/5/38.
33.	Jan. Duncan	4½	3/3/38	
34.	Mary Loy	2	4/3/38	
35.	Jas.Muirhead	4½	7/3/38	Admitted with scalp wound.
36.	Agnes McKay	3	8/3/38	
37.	Carnie Smith	3	10/3/38	Rhinitis 17/3/38.
38.	Isa. McKay	3	10/3/38	Adenitis 16/3/38.
39.	John Walker	2½	10/3/38	Adenitis 13/3/38; Rhinitis 14/3/38.
40.	Cath.Brechin	4½	11/3/38	
41.	Helen Hogg	2½	11/3/38	
42.	Joan Lear	3½	12/3/38	
43.	James Harper	1¾	13/3/38	Rhinitis 20/3/38.
44.	Helen McLaren	4	21/3/38	
45.	D.McKendrick	2¼	23/3/38	
46.	George Fraser	4½	23/3/38	
47.	Rob. Baxter	4	23/3/38	Adenitis 30/3/38.
48.	Jessie Hislop	3	25/3/38	
49.	David Marshall	3	26/3/38	Adenitis 30/3/38.
50.	Molly Milne	4½	27/3/38	Rhinitis on admission.
51.	Ian Smith	3	27/3/38	Rhinitis on admission.
52.	Thos. Ross	2	28/3/38	Adenitis 9/4/38; Rhinitis 11/4/38.
53.	R. Hutchison	4		
54.	Bern. Duffy	3	30/3/38	Adenitis 3/4/38.
55.	Hetty Reilly	4	30/3/38.	

From the beginning of March to the 15th of April all the cases within this ward were swabbed daily and the haemolytic streptococci, when present, were typed.

When discharges occurred in the cases showing complications, cultures were made from these and not from throat swabs. Where no discharges were present, the ordinary throat swab was taken.

The investigation was carried out from March 1st to April 15th 1938.

(The figures in red in the next table represent the types present in the patients on the days the complications were first noted.

D stands for the dates on which the patients were discharged from the hospital.

(-) indicates that the strain could not be typed.

(0) shows that the swab was negative).

(Table of results of Investigation on next page)

Table Showing Relationship between Cross-Infection, Complications and Types of Haemolytic Streptococci

Dates on which swabs were taken

No. of Patient:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Type on Admission:	1	1	3	–	1	2	0	1	1	1	4	1	–	4	1	1	–	–	1	1	3	–	1	4	1	0
2·3·38	1	4	0	1	0	2	0	2	2	0	4	1	–	4	1	1	–	1	1	1	3	–	1	4	1	0
3·3·38	1	0	0	6	0	2	0	2	2	0	4	1	–	4	1	0	–	1	1	1	3	–	1	4	1	0
4·3·38	1	0	1	6	0	2	0	2	2	0	4	1	–	0	1	1	–	0	1	0	3	–	1	4	1	0
5·4·38	D	0	1	6	0	2	0	1	3	1	4	1	–	4	1	0	–	0	1	1	3	–	1	4	1	0
6·3·38		0	1	6	0	2	0	1	3	1	4	1	–	0	1	0	–	1	1	3	3	–	0	4	1	0
7·3·38		0	1	6	–	2	0	1	3	1	4	1	–	0	1	0	–	–	1	1	3	–	0	4	1	3
8·3·38		4	1	–	–	2	0	1	3	0	4	0	–	0	1	0	–	–	1	1	3	–	1	4	1	3
9·3·38		0	0	–	–	4	0	0	3	1	0	0	–	4	–	0	–	0	0	1	0	–	–	4	1	3
10·3·38		0	1	–	–	4	0	1	3	0	4	0	–	4	–	0	–	0	0	0	0	–	–	4	1	3
11·3·38		0	1	–	–	4	0	1	3	1	0	0	–	4	–	0	–	1	1	1	0	0	0	4	1	3
12·3·38		D	D	–	–	4	D	D	3	D	0	0	–	4	–	0	–	1	0	0	0	0	0	0	1	3
13·3·38				–	–	4			0		0	0	–	4	–	0	–	0	1	1	0	1	–	0	1	11
14·3·38				–	4	4			3		4	0	–	4	–	11	–	0	1	1	0	0	0	0	1	11
15·3·38				–	0	4			D		4	D	–	D	–	11	–	3?	0	1	0	0	1	4	1	11
16·3·38				–	0	4					0		–		–	11	–	1	0	0	0	4	1	0	1	11
17·3·38				–	0	4					0		0		–	0	–	1	0	0	0	4	1	0	1	11
18·3·38				–	1	4					0		–		–	0	–	1	0	0	0	4	0	0	1	11
19·3·38				1	1	4					4		–		–	11	–	D	1	D	0	4	4	0	1	11
20·3·38				1	1	4					0		0		–	0	–		11		0	4	4	4	1	11
21·3·38				1	1	4					0		0		–	0	–		1		–	4	4	0	0	11
22·3·38				1	1	4					11		0		–	0	–		0		–	4	4	0	1	11
23·3·38				1	1	4					4		0		–	4	0	0	1		–	4	4	0	0	11
24·3·38				1	1	4					4		0		–	0	–	0	1		–	4	4	0	1	11
25·3·38				1	1	0					0		–		–	4	0	0	1		–	4	4	0	1	11
26·3·38				1	1	4					0		0		–	4	0	0	1		D	0	D	0	D	0
27·3·38				0	1	4					0		0		–	4	0	–	1			–	4	3	0	
28·3·38				0	1	4					4		0		–	14	0	–	1			–	3	0	0	
29·3·38				0	1	4					D		0		–	11	D	0	1			–	3	3	D	
30·3·38				1	1	0							0		–		0	–	1			–	3		0	
31·3·38				1	1	0							0		–		0	–	1			–	1		0	
1·4·38				1	1	0							0		–		0	–	1			–	3		0	
2·4·38				D	1	0							0		–		0	–	1			–	0		0	
3·4·38					0	0							0		–		0	–	1			–	0		0	
4·4·38					1	0							0		–		0	–	1			–	0		0	
5·4·38					1	0							0		–		0	–	1			–	0		0	
6·4·38					0	4							0		–		0	–	1			–	0		0	
7·4·38					0	0							0		–		0	–	1			–	0		0	
8·4·38					1	0							0		–		0	–	1			–	0		0	
9·4·38					D	0							0		–		0	–	1			–	0		0	
10·4·38						0							0		–		0	–	1			–	0		0	
11·4·38						0							0		–		0	–	1			–	0		0	
12·4·38						4							0		–		0	–	1			–	0		0	
13·4·38						4							0		–		0	–	1			–	0		0	
14·4·38						0							0		–		0	–	1			–	0		0	
15·4·38						0							0		–		0	–	1			–	0		0	

Dried of acute Streptococcal Pneumonia. Types isolated from throat p.m.

No. of Patient:	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
Type on Admission:	1	1	1	1	–	1	–	2	1	2	1	3	3	1	–	1	1	1	0	1	3	1	4	1	1	1	1	4	1
2·3·38	1	1	1	1	–	1	–																						
3·3·38	1	1	1	1	–	1	–																						
4·3·38	1	1	1	0	–	1	–	2																					
5·4·38	1	1	1	1	–	1	–	2																					
6·3·38	1	1	0	–	0	0	–	2																					
7·3·38	1	1	1	–	–	1	–	2	1																				
8·3·38	1	1	1	–	–	1	–	2	1	2																			
9·3·38	1	1	1	–	0	3	0	2	1	2																			
10·3·38	1	11	0	–	0	3	–	0	1	2	1	3	3																
11·3·38	1	11	0	3	–	3	3	2	1	2	1	3	3	1	–														
12·3·38	1	11	0	3	–	3	3	2	1	2	1	3	0	1	–	1													
13·3·38	0	11	0	0	–	3	0	2	1	0	1	3	3	1	–	1	1												
14·3·38	1	11	0	0	0	3	0	2	1	2	1	11	3	1	–	1	1												
15·3·38	1	11	0	0	–	3	0	0	1	0	1	11	3	1	0	1	1												
16·3·38	0	11	0	3	–	3	0	0	1	0	11	11	0	1	0	1	0												
17·3·38	0	11	0	0	–	3	0	2	1	0	11	11	0	1	–	1	0												
18·3·38	0	11	0	0	–	3	/	2	1	11	11	11	0	1	–	0	4												
19·3·38	0	11	0	1	0	3	0	0	1	11	11	11	3	1	–	1	4												
20·3·38	0	11	0	1	–	3	–	0	1	0	11	11	3	1	0	1	4												
21·3·38	0	11	4	1	0	3	0	3	1	0	11	11	3	1	–	1	4	1											
22·3·38	0	11	4	1	0	3	0	0	1	0	11	11	3	1	–	1	4	1											
23·3·38	0	11	4	1	0	3	0	0	1	2	11	11	3	1	–	1	4	0	0	1	3								
24·3·38	0	0	4	0	0	0	0	0	1	2	11	0	3	1	–	1	4	2	0	1	3								
25·3·38	0	11	4	1	0	0	0	4?	1	2	11	11	0	10?	0	1	4	2	–	1	3	1							
26·3·38	D	0	4	0	0	0	0	0	0	0	11	0	3	1	0	0	4	0	0	1	3	1	4						
27·3·38		0	4	0	–	0	0	0	1	2	11	0	0	0	0	0	4	1	0	1	3	1	4	1	1				
28·3·38		1	4	0	0	0	0	0	1	2	0	11	0	1	1	0	4	1	–	1	3	1	4	1	1	1			
29·3·38		0	4	D	D	3	D	0	1	2	0	0	0	1	0	1	4	1	0	1	3	0	4	0	1	1	1		
30·3·38		0	4			3		0	1	2	11	1	1?	1	1	0	4	1	0	0	3	1	4	1	1	1	1	4	1
31·3·38		0	4			0		0	1	0	0	1	0	0	1	1	4	1	0	1	3	1	4	1	1	0	1	4	1
1·4·38		0	4			3		0	1	2	0	1	0	0	0	1	4	1	0	1	3	1	4	1	1	0	0	4	1
2·4·38		D	4			0		0	D	2	0	0	0	0	0	1	4	0	0	1	3	1	4	4	1	0	1	0	1
3·4·38			4			0		1		2	0	0	0	0	–	0	4	11	0	0	0	4	4	4	1	4	1	4	1
4·4·38			4			0		0		2	0	1	1	0	–	0	0	0	0	2	3	0	4	0	1	4	1	4	1
5·4·38			0			2		D		D	D	0	0	0	D	1	4	0	0	2	0	0	4	0	0	0	0	4	0
6·4·38			4			0						0	0	1		1	4	0	0	2	0	0	4	1	1	0	0	4	1
7·4·38			0			4						0	0	1		1	0	11	0	2	0	0	4	1	1	6	1	4	1
8·4·38			0			0						1	0	0		1	4	11	0	2	0	0	4	0	1	6	1	4	1
9·4·38			0			4						D	D	0		D	4	11	0	0	3	0	4	0	1	6	6	4	4
10·4·38			0			0								0			4	11	0	0	3	1	0	0	1	6	1	4	1
11·4·38			0			0								0			4	0	0	11	0	1	4	0	1	6	1	–	1
12·4·38			0			4								11			4	0	6	11	0	0	0	6	1	6	0	–	0
13·4·38			0			4								11			0	0	6	0	0	0	4	6	1	6	1	–	1
14·4·38			0			0								0			4	0	6	0	3	1	4	0	0	6	1	0	1
15·4·38			0			0								0			0	1	6	6	0	1	4	1	1	6	2	4	1

A number of facts are evident in the table:

(1) It is seen that after the patient enters the ward the type of haemolytic streptococcus, which caused the scarlet fever, persists for an average of nine days (limits 2 to 16) in the throat before it is replaced temporarily or permanently during the illness.

(2) The exception to this is when the original type produces a complication, as in cases 11, 39, 47, 49. In such a case the original type persists for a longer period, which may extend throughout the illness.

(3) Out of the eight cases which were swabbed and typed daily from admission to discharge from hospital, only two cases did not show, at some period or other, any cross infection.

(4) Of the 55 cases observed, 37 yielded two or more types of haemolytic streptococci at various times.

The cases may be divided as follows:-

No haemolytic streptococci ...	1.
1 type present	17.
2 types present	22.
3 types present	8
4 types present	6
5 types present	1

This observation points to the fact that a considerable amount of cross infection occurs in the wards.

(5) Two or three days prior to the onset of the clinical manifestations of complications there are found in the throats of the patients the same types apparently responsible for the complications. It therefore appears that an incubation period of two to three days (extremes 1 to 4) is necessary for the strains of streptococci to establish their pathogenesis.

(6) Before a new strain becomes established in the throat of a patient a period of some days elapses during which the previous strain appears to decrease or die out. This was found to be the case in the majority of patients. There were, however, exceptions as is seen in cases 4, 6, 9, 15, 26, 28, etc., where one type was suddenly replaced by another.

(7) After three weeks in hospital the number of positive swabs in each case steadily decreased. Negative swabs, however, did not exclude of the type last found in the throat still being present. In case 6, 4.4., seven negative swabs were followed by a reappearance of type 4; then five negative swabs were obtained before this type was again seen. Case 26 shows a similar result - six negative swabs were obtained before type 11 again reappeared. Another good example is case 31.

Such a recurrence of a type may be accounted for by fresh infection with a similar type. This point was investigated in a patient placed in a

cubicle by herself (Constance Sinclair, cubicle 1.). She showed type 1. Daily swabs were taken with the following results:- 1,1,1,1,0,1,1,0,0,1,1,1,1,1,1,0, 0,0,1,1,1,0,0,0,0,1,0.

This single case gave sufficient evidence that three or four negative throat swabs do not exclude the possibility that a positive throat swab may be obtained and from which the type last found in the patient may be cultured.

(8) With regard to the types of haemolytic streptococci which were found to produce complications,

type 3 accounted for 6,
" 4 " " 8,
" 6 " " 1,
" 11 " " 3, and untyped strains
" " 3.

(9) The untyped strains are interesting. Case 22 developed nephritis and an unknown strain was isolated from the urine. Case 15, a week later, also developed nephritis due to an unknown strain, and similarly with case 21, who had haematuria twelve days after the last case. No nephritis due to known strains was observed.

(10) Case 15 was interesting. After the seventh day of swabbing the original type was replaced by type 11. This produced nephritis on the third day after its appearance, and three days later, right and left sided adenitis. For five days the patient

appeared to improve, but the unknown strain persisted. A sudden rise of temperature to 102° F. then occurred and signs of broncho-pneumonia supervened. As the patient sank type 4 made its appearance along with the unknown strain. A few days before death type 4 alone was found. After death swabs were taken far down the throat with a cervical swab. Forty colonies were picked off with the following results:-

33 colonies ... type 4;
6 colonies ... unknown type;
1 colony .... type 11.

This is the only case that was met with throughout this work which had three types of haemolytic streptococcus present in the throat at one and the same time.

(11) It is difficult to account for the sudden outburst of type 6 cross-infections after 7/4/38. Six cases were infected by this type within the course of a week. The last occasion when type 6 was found was on 7/3/38 in case 4. As the case, however, remained in the ward till 2/4/38 there is the possibility that this type was still being dispersed through the ward. On the other hand it may have been carried into the ward by the nursing staff.

I N V E S T I G A T I O N VI.

The object of this investigation was to ascertain whether any correlation existed between particular strains of haemolytic streptococci and complications. With this object in view all cases from September 1st, 1937, to March 31st, 1938, June 1st to June 30th, 1938, and September 1st to December 31st, 1938, were swabbed on admission. When complications occurred the cases were again swabbed.

The following table represents the result of this investigation. The "type" in black represents the one found on admission; that in red is the "type" found when the complication occurred: (The number of the patient refers to the cases to be found in Appendix B.)

Number	Age.	Type.	Complications.	Type.	Days in Hospital.
1	4	1	Otorrhoea (R) on 37th day. Late adenitis and measles.	4	70
2	3	1	Late adenitis and measles	3	55
3	6	4	Late adenitis	4	29
4	5	1	Rhinitis and adenitis	-	37
5	1¾	1	Otorrhoea (R) on 8th day. Discharged for 39 days.	2	55
6	6	1	Otorrhoea (L) on 7th day. Lasted for 17 days. Rhinitis.	4	32
7	8	8	Arthritis of right wrist on 7th day.	1	25
8	8	1	Otitis (R) Rhinitis & Arthritis.	8	65

Number	Age.	Type.	Complications.	Type.	Days in Hospital
9	3	1	Otorrhoea (L) on 9th day. Discharged for 13 days. Late adenitis.	1	27
10	16	1	Otorrhoea (R) on 22nd day Discharged for 23 days.	4	47
11	6	-	Rhinitis.		49
12	3	1	Nephritis & haematuria on 24th day. Duration - 10 days. Late adenitis.	8	56
13	3½	1	Late adenitis	2	52
14	5	2	Late adenitis	15	28
15	8	1	Late adenitis	1	24
16	3½	-	Late adenitis	2	26
17	3	2	Rhinitis	1	85
18	1½	-	H.S. Tonsillitis. Late adenitis.	-	33
19	7	1	Rhinitis. Tonsillitis.	1	33
20	3	1	Late adenitis with abscess formation.	27	52
21	32	4	Toxic Scarlet. Died.	4	11
22	4	1	Otorrhoea on 11th day. Discharged for 59 days. Late adenitis.	4	100
23	6	-	Late adenitis	2	44
24	10	1	Arthritis in fingers on 7th day. Otorrhoea (R) on 14th day. Discharged for 40 days. Late adenitis.	2	60
25	4	1	Late adenitis	1	41
26	5½	-	Late adenitis	4	33
27	37	2	Arthritis in hands on 8th day.	4	26
28	6	1	Late adenitis.	2	37
29	5	4	Otorrhoea (R) on 21st day. Discharged for 5 days. Rhinitis & conjunctivitis.	6	39

Number	Age.	Type.	Complications.	Type	Days in Hospital
30	2	1	Otorrhoea (R) on 11th day. Otorrhoea (L) on 15th ". Discharged (R) - 27 days. (L) - 15 days. Rhinitis and late adenitis.	4	62
31	6	1	Late adenitis	1	38
32	1¼	1	Late adenitis	2	31
33	2½	22	Late adenitis	1	27
34	3	1	Late adenitis	15	33
35	2½	11	Rhinitis	1	26
36	5½	1	Late adenitis	2	29
37	5	1	Otorrhoea, Mastoid on 46th day. Discharged for 44 days.	15	120
38	¾	-	Rhinitis	-	36
39	12	0	Adenitis	1	25
40	2½	4	Otorrhoea (R) commenced on 5th day. Late adenitis.	4	44
41	4	1	Late adenitis	2	27
42	1½	1	Late adenitis	8	27
43	5	1	Otorrhoea(L). Commenced on 10th day. Discharged for 22 days. Otorrhoea(R). Commenced on 3rd day. Discharged for 30 days.	4	55
44	2	-	Late Adenitis.	1	27
45	6	4	Otorrhoea(R) commenced 5th day. Late adenitis.	4	71
46	3½	11	Late adenitis & Rhinitis.	1	67
47	5	1	Otorrhoea(R) commenced on 27th day. Discharged for 15 days. Otorrhoea(L) commenced on 9th day. Discharged for 86 days. Mastoid operation.	4	109
48	3½	1	Late adenitis.	1	27

No.	Age.	Type.	Complications.	Type.	Days in Hospital
49	7	-	Late adenitis	2	45
50	6	1	Late adenitis	25	27
51	8	1	Polyarthritis commenced on 9th day.	2	32
52	4½	2	Late adenitis	1	46
53	5	4	Otorrhoea(L) commenced on 20th day. Late adenitis.	4	106
54	5	-	Rhinitis and Late adenitis	1	76
55	9	28	Arthritis in both wrists: Commenced on 6th day.	28	27
56	3	1	Late adenitis.	4	27
57	8	1	Late adenitis.	4	26
58	6	1	Otorrhoea(R & L); commenced on 8th day. Vaginitis.	3	90
59	6	1	Otorrhoea(R) commenced on 13th day.	1	64
60	26	1	Peritonsillar abscess; commenced on 6th day.	2	30
61	2	0	Late adenitis	1	26
62	3	1	Late adenitis	15	28
63	5	1	Rhinitis	-	54
64	10	-	Late adenitis	-	30
65	3	15	Late adenitis	1	26
66	4	1	Late adenitis & Rhinitis.	3	63
67	6	1	Late adenitis	1	43
68	14	0	Rhinitis.	0	40
69	6	4	Otorrhoea(R) commenced on 6th day. Discharged for 22 days.	-	34
70	4½	1	Otorrhoea (R)	-	36
71	17	1	Adenitis	1	28

No.	Age.	Type.	Complications.	Type	Days in Hospital
72	3	2	Otorrhoea(R) commenced 12th week. Otorrhoea(L) commenced 7th week. Discharge lasted (R)12 and (L) 63 days.	4 4	118
73	17	4	Polyarthritis on 8th day. Late adenitis.	4	29
74	7	1	Late adenitis.	1	28
75	4	1	Rhinitis and adenitis.	0	47
76	7	1	Polyarthritis on 11th day. Late adenitis - abscess.	1	52
77	3	-	Late adenitis & Measles.	0	72
78	25	-	Polyarthritis on 5th day.	-	36
79	2½	1	Late adenitis.	2	92
80	2½	8	Late adenitis	6	71
81	2	1	Late adenitis.	6	99
82	7	4	Otorrhoea(L); commenced on 5th day. Discharged for 17 days. Adenitis.	4	39
83	11	1	Late adenitis.	2	30
84	4½	1	Late adenitis.	6	120
85	3	-	Otorrhoea(L); commenced on 25th day. Discharged for 62 days. Mastoiditis.	4	101
86	6	1	Rhinitis and Late adenitis.	2	37
87	3½	1	Adenitis, chickenpox and measles.	1	97
88	1¼	4	Late adenitis.	4	31
89	2¾	-	Otorrhoea(R); commenced on 21st day. Discharged for 64 days. Late adenitis, chicken pox and rhinitis.	1	89
90	12	1	Otorrhoea(R); commenced on 9th day. Discharged for 19 days.	-	33

No.	Age.	Type.	Complications.	Type.	Days in Hospital
91	7	-	Otorrhoea(L); commenced on 12th day.	15	64
92	6	1	Rhinitis,	6	38
93	2¾	1	Otorrhoea(R). Late adenitis.	1	49
94	12	1	Late adenitis.	4	28
95	5	0	Vaginitis.	1	55
96	4	-	Vaginitis.	0	31
97	7	1	Otorrhoea(R); commenced on 15th day. Discharged for 30 days.	4	57
98	7	1	Adenitis - 7th day.	28	28
99	6	-	Adenitis - 15th day.	-	25
100	10	4	Arthritis of shoulder - 7th day.	1	28
101	7	1	Rhinitis - 5th day.	2	31
102	15	1	Arthritis of wrists - 3rd day.	2	26
103	10	1	Otorrhoea(L) - 6th day; lasted 70 days. Otorrhoea (R) - 38th day. Lasted 58 days. Vaginitis.	4 4 B.coli	99
104	5	-	Adenitis - 16th day Rhinitis - 42 day.	-	78
105	8½	2	Adenitis - 8th day.	11	28
106	5	8	Otorrhoea - 7th day and Aden itis. Dysentry carrier.	2	126
107	10	1	Arthritis - 3rd day.	1	29
108	22	1	Arthritis - 4th day. Adenitis - 7th day.	1	37
109	27	1	Arthritis - 5th day.	2	31
110	5	1	Otorrhoea(R) - 4th day. Lasted 20 days.	1	26
111	9	8	Adenitis - 21st day.	27	36
112	6	1	Adenitis - 11th day.	4	30

No.	Age.	Type.	Complications.	Type.	Days in Hospital
113	10	-	Otorrhoea on admission. Chickenpox - 15th day. Arthritis - 28th day. Pericarditis + 23rd day.	- 3 3	108
114	5	1	Otorrhoea - 16th day. Lasted 50 days.	15	48
115	16	1	Otorrhoea(L) - 10th day. Lasted 7 days.	15	27
116	8	1	Adenitis(R) - 5th day. Chickenpox - 39th day.	3	50
117	13	1	Adenitis - 18th day Arthritis & Endocarditis - 23rd day.	4 4	65
118	8	-	Adenitis - 3rd day.	-	26
119	8	1	Adenitis - 12th day.	S.viridans.	54
120	10	0	Adenitis - 5th day.	1	25
121	12	-	Otorrhoea - 6th day.	3	56
122	6	1	Adenitis(R) - 6th day.	2	28
123	11	-	Arthritis of hands - 4th day.	2	27
124	13	0	Adenitis(R) - 23rd day.	8	62
125	5	1	Adenitis(L) - 21st day.	8	27
126	12	1	Adenitis - 4th day. Chickenpox - 9th day.	1	37
127	5	1	Adenitis - 17th day.	-	34
128	27	-	Adenitis - 15th day.	-	31
129	8	1	Adenitis - 17th day.	3	40
130	13	-	Early Adenitis.	-	30
131	11	1	Arthritis - 6th day.	1	27
132	9	2	Early Adenitis.	27	33
133	27	1	Otorrhoea(L) - 6th day. Otorrhoea(R) & Rhinitis - 11th day.	1 1	43

No.	Age.	Type.	Complications.	Type.	Days in Hospital
134	3½	0	Late Adenitis. Chickenpox.	1	53
135	2½	2	Late Adenitis	3	88
136	4½	1	Otorrhoea - 47th day. Lasted 22 days. Adenitis & Measles.	4	80
137	6	2	Otorrhoea(R) - & Cellu-titis of right ear - 12th day.	1	138
138	4¾	-	Late Adenitis and Measles.	4	77
139	3	1	Late Adenitis and Chickenpox.	2	88
140	12	1	Early Rhinitis.	2	29
141	2½	1	Otorrhoea(L) - 12th day. Lasted 57 days. Adenitis.	4 4	75
142	2	-	Otorrhoea(R) - 10th day. 31 days. Chickenpox.	-	51
143	1	1	Late Adenitis & Rhinitis. Measles, Chickenpox & Pneumonia	Mixed culture 4	113
144	4	-	Otorrhoea(L) - 13th day. Otorrhoea(R) & Mastoid.	- -	133
145	5	1	Otorrhoea(L) - 12th day. Late Adenitis.	- -	51
146	7	0	Otorrhoea - 29th day. Lasted 14 days.	3	55
147	4	1	Otorrhoea(L) - 5th day. Otorrhoea(R) - 10th day.	1 1	39
148	2½	-	Rhinitis.	-	58
149	3½	1	Rhinitis	1	95
150	3	1	Early Adenitis & Rhinitis.	1	39
151	11	1	Early Adenitis.	28	25
152	8	2	Early Adenitis.	2	27
153	9	1	Late Adenitis.	-	30

No.	Age.	Type.	Complications.	Type	Days in Hospital
154	2	1	Otorrhoea(R) - 7th day.	15	38
155	3	1	Late Adenitis & Rhinitis. Measles.	S.viridans.	84
156	16	2	Early Adenitis	1	33
157	2	-	Late Rhinitis. Measles and Chickenpox.	-	72
158	6	1	Otorrhoea - 14th day. Lasted 21 days.	Mixed Culture.	42
159	1	1	Late Rhinitis.	-	49
160	6	-	Otorrhoea(L) - 17th day. Lasted 7 days.	2	38
161	4	1	Otorrhoea(R) - 12th day. Adenitis.	1	41
162	12	2	Late Adenitis & Otorrhoea(R) - 21st day.	3	54
163	8	-	Late Adenitis.	-	44
164	2	1	Late Adenitis & Chickenpox.	2	44
165	8	1	Otorrhoea(R) - 11th day. Otorrhoea(L) & Mastoid	3 3	113
166	6½	1	Nephritis - 19th day. Lasted 12 days. Adenitis.	6 6	74
167	8	1	Early Adenitis.	Mixed culture.	32
168	1	-	Early Rhinitis	1	27
169	3	1	Otorrhoea(R) - 4th day. Mastoid & Rhinitis.	4 4	146
170	6	0	Early Rhinitis	3	26
171	6	1	Late Adenitis	1	31
172	2¾	1	Otorrhoea(R) - 13th day Otorrhoea(L) - 14th day. Late Adenitis.	2 2 2	53
173	8	-	Late Adenitis - 20th day.	1	39
174	5	27	Otorrhoea(R) - 20th day. Discharged for 35 days.	4	63
175	8	2	Late Adenitis.	4	54

No.	Age.	Type.	Complications.	Type	Days in Hospital
176	3	1	Late Adenitis. Chickenpox.	4	74
177	4½	-	Otorrhoea(L) - 9th day; discharged 27 days. Otorrhoea(R) - 46th day; discharged 58 days. Late Adenitis.	- 4 4	127
178	4	1	Otorrhoea(R) & Adenitis. Rhinitis.	4 4	64
179	6	4	Otorrhoea - 4th day. Mastoiditis.	3 3	130
180	5	8	Late Adenitis	1	43
181	22	1	Late Adenitis	11	30
182	5¾	1	Late Adenitis & Chickenpox	27	86
183	1¼	1	Late Adenitis & Chickenpox	27	77
184	45	1	Otorrhoea(R) - 12th day; discharged 7 days.	1	28
185	10	2	Adenitis - 3rd day.	11	30
186	5	1	Otorrhoea - 8th day; discharged 30 days.	6	44
187	3	-	Rhinitis & Chickenpox.	4	50
188	2	4	Late Adenitis, Measles & Chickenpox.	4	67
189	5	4	Rhinitis - 17th day.	6	33
190	32	-	Arthritis of fingers and wrists - 3rd day.	-	24
191	8	1	Rhinitis.	-	63
192	3	-	Otorrhoea - 36th day. Adenitis.	- -	52
193	31	1	Arthritis of shoulders - 5th day. Otorrhoea(R) - 15th day.	1 -	36
194	8	1	Otorrhoea(L) - 2nd day.	1	47
195	2½	0	Late Adenitis.	1	38
196	6	2	Otorrhoea(L) - 5th day; discharged 35 days.	S.viridans	47

No.	Age.	Type	Complications.	Type.	Days in Hospital
197	14	-	Late Adenitis.	-	45
198	12	1	Late Adenitis.	4	26
199	35	1	Polyarthritis on admission. Adenitis - 6th day	1 1	23
200	14	4	Otorrhoea(R) & Mastoiditis on admission. Pyrexia - 11th day.	4	87
201	3	1	Late Adenitis	6	40
202	12	3	Septicaemia & Cellulitis. Died	3	3
203	14	1	Otorrhoea (R & L) - 1st day.	1	85
204	5	1	Rhinitis.	1	63
205	5¼	1	Adenitis - 2nd day.	4	37
206	10	1	Arthritis of wrists - 6th day.	Mixed culture	26
207	1¼	0	Adenitis & Rhinitis.	1	75
208	3	-	Otorrhoea(R) - 12th day. Adenitis & Rhinitis.	- 15	68
209	4	1	Adenitis & Rhinitis	Mixed culture	57
210	10	1	Adenitis - 3rd day.	1	28
211	6	1	Otorrhoea(L) - 5th day. Discharged 30 days. Chickenpox.	-	46
212	5	-	Otorrhoea(R) - 14th day.	-	110
213	2	1	Late Adenitis & Rhinitis.	Mixed culture	67
214	9	1	Empyema. Arthritis of wrists - 4th day. Adenitis 32nd day.	St.aureus 1	46
215	20	4	Adenitis - 3rd day. Peritonsillar abscess - 7th day. Chickenpox 19th day.	4 4	34

No.	Age.	Type	Complications.	Type	Days in Hospital
216	8	-	Otorrhoea(R) 5th day. Lasted 23 days. Otorrhoea(L) - 13th day. Lasted 10 days.	- -	44
217	8	1	Early Adenitis.	2	30
218	2½	1	Early Adenitis & Chickenpox	27	38
219	3	3	Late Rhinitis	1	79
220	2	1	Late Adenitis	-	34
221	7½	1	Late Adenitis	1	35
222	5	1	Late Adenitis	-	39
223	4	-	Vaginitis	8	41
224	34	0	Late Empyema (L)	St.aureus	62
225	2½	8	Late Rhinitis.	1	58
226	2½	1	Late Adenitis	27	44
227	1	-	Late Adenitis & Chicpenpox	-	71
228	39	1	Myositis - 3rd day.	1	23
229	7½	1	Vaginitis - 25th day.	B.coli	57
230	8	-	Rhinitis - 12th day.	-	28
231	14½	1	Arthritis - 2nd day.	2	26
232	43	1	Pyrexia - 10th day. (Finger incised). Septic finger on admission.	1	48
233	5	-	Adenitis - 19th day.	-	38
234	10	1	Blood & mucus in stool - 24th day.	-	46
235	8	4	Adenitis - 5th day Arthritis - 6th day.	4 4	
236	11	1	Arthritis - 5th day.	S.viridans	41
237	10	1	Adenitis - 14th day	-	33
238	8	0	Adenitis - 8th day.	1	47
239	15	-	Adenitis - 11th day	-	33
240	37	1	Arthritis on admission	Mixed culture	22

No.	Age.	Type.	Complications.	Type.	Days in Hospital
241	7	-	Vaginitis - 8th day.	8	34
242	14	1	Arthritis - 3rd day.	1	25
243	21	1	Arthritis - 2nd day.	4	26
244	10	1	Adenitis - 6th day	Mixed culture	36
245	10	1	Vaginitis - 16th day	B.coli	45
246	9	4	Adenitis - 5th day	1	47
247	27	-	Arthritis of wrists - 12th day. Myositis - 8th day.	-	25
248	16	1	Adenitis - 8th day.	2	27
249	5	1	Pyrexia - 6th day.	3	74
250	7	1	Vaginitis - 8th day	B.coli	49
251	9	4	Adenitis - 6th day Arthritis - 18th day	4 Mixed culture	40
252	30	1	Otorrhoea(L) - 17th day. Lasted 4 days.	-	29
253	14	-	Septicaemia & Acute Nephritis. DIED.	-	1
254	8	1	Otorrhoea(L) - 19th day. Lasted 7 days.	4	29
255	14	-	Adenitis.	4	45
256	13	1	Late Vaginitis	15	33
257	12½	1	Polyarthritis - 30th day. Otorrhoea (R) - 9th day.	Mixed culture -	88
258	2	-	Adenitis - 8th day Otorrhoea - 16th day.	- 1	20 41
259	3½	1	Vaginitis - 27th day	4	35
260	3½	1	Adenitis - 6th day.	2	32
261	1	1	Rhinitis - 17th day.	4	42
262	4	-	Vaginitis - 19th day.	23	53
263	7	0	Rhinitis (purulent) - 19th day.	1	31

No.	Age.	Type.	Complications.	Type.	Days in Hospital
264	27	1	Arthritis - 12th day.	3	41
265	5	1	Blood in stools - 5th day	28	29
266	5	1	Blood in stools - 11th day. Adenitis - 34th day.	28 1	64
267	4	-	Rhinitis - 6th day. Adenitis - 15th day.	Mixed culture do.	27
268	4½	1	Adenitis - 3rd day. Vaginitis - 21st day.	1 4	36
269	9	2	Adenitis - 6th day.	2	39
270	2½	2	Rhinitis - 23rd day.	4	94
271	1	1	Rhinitis - 31st day.	-	48
272	22	1	Adenitis - 2nd day.	1	27
273	5	1	Submaxillary Adenitis - 12th day. Incised (pus) - 20th day.	15 15	29
274	5½	1	Tonsillitis - 17th day.	25	28
275	3	2	Adenitis - 10th day. Submental Adenitis - 17th day. Rhinitis - 23rd day. Submental abscess incised - 34th day (Pus).	3 S.aureus 8 8	56
276	1	4	Rhinitis - 13th day.	1	28
277	8	1	Otorrhoea(L) - 3rd day. Acute Mastoiditis - 13th day. Operation - 15th day (Pus) Otitis (R) - 23rd day. Pyrexia - 38th day.	1 1 1 4 4	143
278		-	Pyrexia - 8th day.	-	27
279		-	Adenitis (L) - 6th day. Adenitis (R) - 11th day.	- 1	36
280		1	Rhinitis - 25th day.	-	98
281		-	Rhinitis - 7th day.	-	28
282	6	-	Pyrexia - 9th day.	-	44
283	8	1	Adenitis - 25th day.	2	39

No.	Age.	Type.	Complications.	Type.	Days in Hospital
284	8½	1	Rhinitis - 20th day.	3	83
285	8	1	Rhinitis - 3rd day Septic thumb - 24th day (Pus.)	1 1	88
286	8	-	Pyrexia - 8th day.	-	57
287	3	1	Adenitis - 14th day.	2	74
288	3½	2	Pyrexia - 7th day. Rhinitis - 24th day.	1 2	79
289	5½	1	Adenitis - 24th day. Rhinitis - 27th day	1 11	39
290	8	1	Adenitis - 5th day. Rhinitis - 18th day Vaginitis - 28th day.	2 11 11	59
291	7	1	Adenitis - 20th day.	2	37
292	7½	-	Rhinitis - 12th day.	-	35
293	18	0	Vaginitis - 15th day	23	38
294	12	1	Adenitis - 34th day.	15	46
295	9	1	Rhinitis - 25th day.	-	43
296	7	1	Adenitis - 16th day.	2	35
297	5	2	Rhinitis - 17th day.	Mixed culture	26
298	9	0	Rhinitis - 13th day. Septic finger - 29th day (Pus).	1 S.aureus	53
299	7	1	Vaginitis - 15th day.	23	32
300	10	-	Enteritis - 4th day. (Sonne)	-	30
301	9	-	Rhinitis - 3rd day.	-	29
302	8	1	Rhinitis - 10th day.	-	29
303	6	11	Adenitis - 5th day.	11	25
304	6	1	Adenitis - 8th day.	11	30
305	19	1	Mastoiditis - 3rd day.	1	69
306	27	1	Arthritis - 2nd day.	1	33
307	27	1	Adenitis (L) - 25th day.	4	68

No.	Age.	Type.	Complications.	Type.	Days in Hospital
308	1½	1	Rhinitis - 3rd day.	1	30
309	4¼	1	Adenitis - 24th day.	4	36
310	3	3	Adenitis - 2nd day.	1	36
311	3½	2	Rhinitis - 28th day.	4	72
312	3½	1	Vaginitis - 12th day.	S.aureus	27
313	1	1	Rhinitis - 11th day.	3	30
314	1¼	4	Adenitis - 3rd day. Rhinitis - 16th day.	4 4	42
315	2	-	Rhinitis - 8th day.	-	48
316	3	4	Adenitis - 3rd day.	4	25
317	1¾	1	Nephritis - 21st day. Adenitis - 23rd day. Pneumonia - 30th day. Died.	- - -,4,11	38
318	2½	3	Nephritis - 29th day. Adenitis - 31st day.	- -	57
319	4	-	Adenitis - 3rd day. Rhinitis - 6th day. Nephritis - 9th day.	- - 4	53
320	1	1	Rhinitis - 34th day.	4	54
321	1¾	0	Rhinitis - 17th day.	3	39
322	4	1	Adenitis - 12th day.	11	34
323	10	1	Adenitis - 7th day.	2	57
324	35	-	Adenitis - 7th day.	-	33
325	8	1	Adenitis - 6th day.	2	26
326	2½	4	Relapse - 20th day.	11	48
327	3	1	Blood in stool - 11th day (Stool)	28	35
328	17	1	Arthritis - 3rd day. Coryza - 15th day.	1 1	35
329	8	4	Adenitis - 5th day.	27	47
330	6	-	Rhinitis - 11th day.	-	22

No.	Age.	Type.	Complications.	Type	Days in Hospital
331	16	4	Adenitis - 23rd day.	1	35
332	7	1	Rhinitis - 3rd day.	1	44
333	7	1	Adenitis - 2nd day. Rhinitis - 7th day.	4 4	72
334	7	1	Septic Toe - 19th day (Pus)	15	52
335	52	4	Arthritis - 2nd day.	4	29
336	14	1	Arthritis - 4th day.	4	29
337	5	4	Rhinitis - 3rd day.	4	29
338	49	1	Arthritis - 4th day.	4	24
339	21	1	Adenitis - 18th day.	2	31
340.	19	1	Arthritis - 15th day.	2	41
341	6½	1	Adenitis - 24th day. Otorrhoea(R) - 39th day.	15 15	55
342	4	1	Adenitis - 4th day.	1	37
343	4½	2	Adenitis - th day.	6	29
344	2	1	Rhinitis - 7th day Adenitis & Relapse - 31st day. Gland incised - 38th day (pus)	2 3 S.aureus	70
345	7	2	Rhinitis - 11th day	1	40
346	8	-	Adenitis - 7th day.	-	26
347	6	1	Adenitis - 15th day.	27	34
348	44	4	Arthritis - 5th day.	4	24
349	3	1	Rhinitis - 5th day.	1	25
350	1½	1	Rhinitis - 13th day.	4	33
351	5	-	Otorrhoea(R) - 21st day.	15	64
352	3½	0	Vaginitis - 26th day.	1	76
353	7	1	Adenitis - 28th day.	Mixed culture	43
354	8	-	Otorrhoea(R) - 21st day.	-	41
355	3	1	Rhinitis - 22nd day.	2	40

No.	Age.	Type.	Complications.	Type.	Days in Hospital
356	6	1	Adenitis - 10th day (Tonsillitis case)	25	29
357	12	1	Arthritis - 9th day	2	28
358	16	4	Adenitis - 2nd day. Otorrhoea - 6th day.	4 4	47
359	9	1	Adenitis - 5th day.	Mixed culture	32
360	5	0	Pyrexia (Relapse) - 34th day.	1	74
361	7	4	Adenitis - 6th day.	4	25
362	8½	-	Adenitis - 6th day.	4	27
363	8	1	Adenitis - 9th day.	4	26
364	8	1	Adenitis - 10th day.	4	32
365	35	-	Myositis - 5th day.	1	48
366	67	1	Adenitis - 14th day.	-	28
367	6½	1	Empyema case, Pyrexia 22nd day.	4	44
368	5½	1	Vaginitis - 20th day.	25	47
369	10	1	Relapse - 15th day. Arthritis - 23rd day.	3 3	43
370	10	-	Relapse - 14th day. Vaginitis - 18th day.	- 23	38
371	3	1	Rhinitis - 24th day.	4	42
372	3	1	Rhinitis - 8th day.	11	27
373	3	3	Adenitis - 7th day.	11	31
374	2½	3	Adenitis - 4th day. Rhinitis - 5th day.	3 3	31
375	1¾	4	Rhinitis - 8th day.	4	98
376	2¼	-	Adenitis - 35th day.	2	59
377	4½	1	Relapse - 31st day.	2	59
378	4	3	Adenitis - 5th day.	3	49
379	3	4	Adenitis - 5th day.	4	32

No.	Age.	Type.	Complications.	Type.	Days in Hospital
380	4½	4	Rhinitis - 22nd day. Adenitis - 29th day.	4 4	77
381	3	1	Adenitis - 23rd day.	1	80
382	2	1	Adenitis - 13th day. Rhinitis - 15th day.	6 6	46
383	4	1	Rhinitis - 26th day.	1	47
384	3	4	Adenitis - 5th day.	4	49

REMARKS.

The total number of cases showing complications which occurred during the above period was 414, but those cases which were admitted with complications have not been included in the above list.

In the 384 cases noted there occurred 455 complications. These were bacteriologically typed as follows:-

H. S. Strains, etc.	Number of Complications.
Type 1.	99 (21.9 per cent)
" 2.	49 (11.9 " ")
" 3	31 (6.8 " ")
" 4	93 (20.4 " ")
" 6	13 (2.9 " ")
" 8	8 (1.9 " ")
" 11	12 (2.6 " ")
" 15	17 (3.7 " ")
" 23	4 (0.9 " ")
" 25	4 (0.9 " ")

H.S. Strains, etc.	Number of Complications.
Type 27	9 (1.9 per cent)
" 28	6 (1.3 ")
S.aureus	7 (1.5 ")
S.viridans	4 (0.9 ")
Mixed organisms	19 (4.1 ")
B. coli	4 (0.9 ")
Untyped H. S.	76 (17.7 ")
	455

(1) 280 of the complications were produced by strains different from those with which the patients entered hospital.

(2) 92 of the complications were produced by the same strains with which the patient entered hospital.

(3) 49 of the complications were produced by strains which could not be typed, and occurred in those patients who, on entry to hospital, also had untypable strains. These complications, therefore, belong either to group 1 or to group 2.

(4) 34 complications were produced by other types of organisms.

Converted into percentages these figures are:-

1. Complication types different from types on entry: 61.5%
2. Complication types same as types on entry: 20.2%
3. Untypable strains in both cases: 10.8%
4. Complications due to other organisms: 7.5%

(b) Of the 63 patients who developed complications before the fifth day and who had typable strains in their throats, 33 contracted their complications from the same strains they had on entry to hospital. After the fifth day in the wards there was a steady increase in the number of complications due to types of haemolytic streptococci differing from the original ones. Thus after the second week over 90 per cent of complications were due to new strains.

This is very significant for it points to the fact that the longer the patients remain in the wards the more likely are they to become infected with new strains, and so develop complications. This statement must, however, be qualified for it is noted that after the patients have been in the wards for some considerable time the throat swabs become increasingly negative. This appears to indicate that, after a certain time, the longer the patients are exposed to cross infection the greater becomes the immunity to the many types of the haemolytic streptococci.

The following experiment shows the steady decrease of haemolytic streptococci in the throats of cases during their stay in hospital. (Only uncomplicated cases have been selected for this table. Complicated cases with discharges for long periods would obviously be unsuitable to demonstrate the point. Swabs were taken at the end of each week).

(X = positive swab.)
(0 = negative swab.)

Case No.	1st week.	2nd week.	3rd week.	4th week.	During 5th week.
1.	X	X	X	0	0
2.	X	X	0	X	0
3.	X	X	X	X	X
4.	X	0	0	0	0
5.	X	X	X	0	X
6.	X	X	X	0	0
7.	X	X	0	X	0
8.	X	X	X	X	0
9.	X	0	X	X	X
10.	X	X	0	0	0
11.	X	0	X	X	X
12.	X	X	X	X	0
13.	X	X	0	X	0
14.	X	X	0	0	X
15.	0	X	X	0	X
16.	X	X	0	0	0
17.	X	X	X	X	0
18.	X	X	X	0	0
19.	X	X	X	0	0
20.	X	X	0	X	0
21.	X	0	X	0	X
22.	X	0	0	X	0
23.	X	X	0	0	X
24.	X	X	0	0	0
25.	X	X	X	0	0
26.	X	X	X	X	0
27.	X	X	X	0	0
28.	X	X	0	X	X
29.	X	X	X	0	X
30.	X	X	X	0	0

After the 1st week out of 30 cases 1 was negative.
" " 2nd " " " " " 3 were negative.
" " 3rd " " " " " 8 " "
" " 4th " " " " " 15 " "
" " 5th " " " " " 20 " "

This table was not compiled by swabbing a number of patients from a single ward. To obtain this table 121 patients were swabbed weekly and all cases leaving hospital on or before the 28th day have not been included.

The numbers above refer to the following:-

Patients.	Admitted	Days in hospital
1. Annie Irvine	22/11/37	46
2. Elizabeth Devine	20/12/37	30
3. Lucy Douglas	22/12/37	40
4. Agnes Blyth	28/12/37	33
5. Kath. Brogan	3/2/38	38
6. Amelia Clark	12/2/38	32
7. Margaret Conie	21/2/38	34
8. James Stewart	25/2/38	30
9. Gerald Paven	4/3/38	37
10. Winnie Galloway	7/3/38	34
11. Margt. O'Saughness	9/3/38	32
12. Joan Lear	12/3/38	30
13. William McCurdie	23/3/38	32
14. Jane White	30/3/38	35
15. Mary Henderson	4/4/38	30

Patients.	Admitted	Days in hospital
16. Joyce Livingstone	11/4/38	34
17. William Thomas	15/4/38	33
18. Kenneth Fyfe	28/4/38	38
19. Annie Paton	9/5/38	30
20. Thomas Dowie	9/5/38	30
21. Isabella Falconer	16/5/38	30
22. Neil Lynch	19/5/38	31
23. Helen McDonald	23/5/38	33
24. Christina Walker	9/6/38	31
25. Thomas O'Brian	9/6/38	32
26. Arthur Fenning	18/6/38	32
27. Hugh Elliot	22/6/38	32
28. Edward Milligan	24/6/38	30
29. William McPhee	1/7/38	30
30. Elixins Stewart	5/8/38	33

(c) A classification of the types of haemolytic streptococci found on admission in those of the 384 cases who gave positive swabs (viz. 366) is as follows:- (For comparison the number of cases which did not develop complications during the same period is also given.)

Type of H. S.	Number of patients with complications.	Number of patients without complications
1	221 - 60.4%	515 - 55.2%
2	22 - 6.0%	101 - 10.8%
3	4 - 1.1%	52 - 5.6%
4	31 - 8.5%	33 - 3.5%
8	7 - 1.9%	22 - 2.4%

Type of H. S.	Number of patients with complications.	Number of patients without complications.
11	3 - 0.9%	12 - 1.3%
15	1 - 0.3%	12 - 1.3%
22	1 - 0.3%	3 - 0.3%
27	1 - 0.3%	7 - 0.8%
28	1 - 0.3%	2 - 0.2%
Untyped	74 - 20.2%	173 - 18.6%
	366 - 100.0%	932 - 100.0%

The significance of the above facts is not quite clear. The following table of percentages of the first four types may facilitate reasoning.

Types.	Percentage of types of H.S. on admission. Cases later showing complications.	Percentage of types of H.S. in complicated cases.	Percentage of types of H.S. in uncomplicated cases.
1.	60.4	21.9	55.2
2.	6.0	11.9	10.8
3	1.1	6.8	5.6
4	8.5	20.4	3.5

Type 1. The percentages of this type on admission in both complicated and uncomplicated cases were nearly the same (plus-minus 60%). This type accounted for 21.9 per cent of complications. From this it would appear that type 1 is not as pathogenic in its production as the other three types to be considered.

Types 2 and 3. These may be discussed together. In both cases the percentage of types on admission,

in patients who later had complications, was low (6.0 and 1.1 per cent), whereas the percentages of types in the complicated and uncomplicated cases were high (11.9, 6.8 and 10.8, 5.6). The low percentages in column 1 and the high and almost similar percentages in columns 2 and 3 appear to indicate that types 2 and 3 were more pathogenic in producing complications than type 1; but only in those cases which were admitted without this type.

Type 4. Relatively there were twice as many admissions with this type (showing complications later) as uncomplicated cases with this type (8.5% : 3.5%). Furthermore this type was present in 20.4 per cent of complications. Type 4 is highly interesting, because 20 of the 31 cases (see page 95) who were admitted with this strain also developed complications from it. This indicates the high pathogenicity of which this strain of haemolytic streptococcus is capable. This fact is further borne out when we consider that only 3.9 per cent of uncomplicated cases were admitted with this type.

The general conclusion is that type 1 is not highly conducive to complications, but that these probably arise from this strain by its preponderance in the wards, considering that over 50 per cent of cases admitted are due to this type.

Types 2 and 3 are more pathogenic than type 1, but only in cases not admitted with these types.

Type 4 is highly pathogenic and accounted for 20.4 per cent of the complications, about as many as that produced by type 1, but which accounted for seven times as many admissions.

When the other types 8, 11, 15, 22, and 27 are considered on the above basis, it is found that they fall into the same class as types 2 and 3. They produce from 0.9 to 3.7 per cent of complications, but most of the complications occur in patients admitted with other types, particularly type 1. Type 15 appears to be slightly more pathogenic than the other types.

Type 28 falls into the same category as type 4. This conclusion is the result of an investigation which was carried out May 1938 and will be referred to later.

SECTION 3.

Correlation of Bacteriological and Clinical Findings.

(a) Uncomplicated cases.

Of the 1,432 cases swabbed during September to December 1937, January to March 1938, and June of the same year, 949 of those which gave positive swabs were uncomplicated.

These were typed as follows:-

Type 1	---	515
" 2	---	101
" 3	---	52
" 4	---	33
" 6	---	6
" 8	---	22
" 11	---	12
" 15	---	12
" 22	---	3
" 23	---	2
" 25	---	9
" 27	---	7
" 28	---	2
Untyped	---	173
T o t a l		949

Of these types, 1, 8, 11 and 25 showed the mildest form of scarlet fever, and the patients had an average stay of 24.8 days in hospital.

Types 2, 15, 22, 23, and 28 produced a scarlet fever which necessitated an average stay of 27.8 days in hospital.

Type 15 caused twelve patients to remain in hospital for an average period of 30.7 days.

The average number of days for types 3, 4, 6 and 27 was 34.

It remains evident that type 4 was one of the most pathogenic of the strains encountered.

(b) Complicated Cases.

To show the relationship between bacterial types and complications the following table (see next page) has been compiled:-

(For the sake of convenience these abbreviations have been adopted:-

Ad. - Adenitis.
Ot. - Otorrhoea.
Ar. - Arthritis
En. - Endocarditis.
Rh. - Rhinitis.
Ma. - Mastoiditis.
Va. - Vaginitis.
Ne. - Nephritis.
Py. - Pyrexia.
Re. - Relapse.
O.C. - Other Complications.)

Type	Ad.	Rh.	Ot.	Ma.	Ar.	Va.	En.	Ne.	Py.	Re.	O.C.
1.	41 43·2%	19 20·0%	15 15·8%	2 2·1%	11 11·9%	2 2·1%	- -	- -	1 1·1%	1 1·1%	My.2 (2·1%) LS.1 (1·1%)
2.	27 58·7%	5 10·9%	6 13·0%	- -	6 13·0%	- -	- -	- -	- -	1 2·2%	Pa.1 (2·2%)
3.	10 31·3%	5 15·6%	7 21·9%	1 3·1%	3 9·4%	1 3·1%	- -	- -	1 3·1%	2 6·3%	Pe.1 (3·1%) D.1 (3·1%)
4.	30 32·9%	15 16·5%	25 27·5%	2 2·2%	8 8·8%	3 3·3%	1 1·1%	1 1·1 %	3 3·3%	- -	Pa.1 (1·1%) D.1 (1·1%) Pn.1 (1·1%) TS.1 (1·1%)
6.	6 60·0%	2 20·0%	2 20·0%	- -	- -	- -	- -	- -	- -	- -	
8.	4 36·4%	2 18·2%	1 9·1%	- -	1 9·1%	2 18·2%	- -	1 9·1%	- -	- -	
11.	6 54·5%	3 27·3%	- -	- -	- -	1 9·1%	- -	- -	- -	1 9·1%	
15.	7 43·8%	1 6·3%	5 31·3%	1 6·3%	- -	1 6·3%	- -	- -	- -	- -	LS.1 (6·3%)
23.	- -	- -	- -	- -	- -	3 100·0%	- -	- -	- -	- -	
25.	2 33·3%	- -	- -	- -	- -	2 33·3%	- -	- -	- -	- -	To.2(33·3%)
27.	9 100.%	- -	- -	- -	- -	- -	- -	- -	- -	- -	
28.	2 33·3%	- -	- -	- -	1 16·7%	- -	- -	- -	- -	- -	En.3 (50·0%)
-	25 37·3%	13 19·4%	19 28·4%	- -	3 4·5%	- -	- -	3 4·5%	1 1·5%	1 1·5%	D.1 (1·5%) To.1(1·5%)

This table does not take into account the complications caused by other organisms than haemolytic streptococci.

Adenitis.

Of the 404 complications 169 were adenitis. Type 1 had the highest number, namely 41. Types 2, 4, and certain unknown strains accounted for 82 of the cases.

Of all the types, 27 showed a greater tendency than any other to produce this complication. Only 9 such cases were recorded, and all 9 were adenitis (100 p.c.). After this came type 6 with 60 p.c., then type 2 with 58.7 p.c. and type 11 with 54.5, thereafter types 1, 3, 4, 8, 15, 25 and 28. Of the frequently occurring types, 2 is the most important, for, as we have seen, more than half of the complications it produced were adenitis.

Rhinitis.

This condition was present in 65 out of the 404 complications.

Type 1 again accounted for the highest number of cases, namely 19, of all the types. The unknown strains accounted for 13 cases, and type 4 for 15 cases.

Type 11 had the highest predilection to produce this complication, - 27.3 p.c. of all complications due to this type being rhinitis. Thereafter came type 6 with 20 p.c., unknown strains with 19.4 p.c., type 8 with 18.2 p.c., and types 4 and 3 with 16.5 p.c. and 15.6 p.c. respectively. Of the common types these last two showed the greatest tendency to produce rhinitis, particularly type 4.

Otorrhoea.

80 of the 404 complications were otorrhoea.

Type 4 produced the greatest number of cases, namely 25; thereafter the unknown strains accounted for 19, and type 1 for 15.

Type 15 showed the greatest tendency to produce this complication. 31.3 p.c. of all complications from this type were otorrhoea. Of the common types, 4 is the most important for 27.5 of the complications produced by this type were otorrhoea.

Mastoiditis.

6 cases occurred among the 404 complications. Types 1 and 4 were the highest, with two cases each.

Type 15, as in otorrhoea above, was the type with a greater tendency than any other to produce this complication.

Arthritis.

33 of the 404 complications were arthritis. Type 1 had the highest number, namely 11. Type 2 on the other hand had the greatest proclivity to produce this complication.

Vaginitis.

15 cases occurred among the 404 complications. Types 4 and 23 each produced three cases and were the highest recorded for the various types.

The greatest tendency to produce this complication was shown by type 23. 100 per cent of complica-

tions due to this type were vaginitis. Thereafter came type 25 and then type 8.

Nephritis.

Of the 404 complications 5 were nephritis. Certain unknown types accounted for 3 of the 5 cases. The other 2 were caused by types 4 and 8. In terms of percentages, type 8 showed the greatest proclivity for producing this complication.

Deaths.

Three deaths occurred due to types 3, 4, and some unknown type respectively.

Type 3 showed the greatest tendency for causing death. 3.1 per cent of complicated cases due to this type died.

The other complications can more conveniently be studied on the table given on page 99.

The only types which deserve separate mention are 25 and 28. 33.3 p.c. of type 25's complications were tonsillitis. 50 p.c. of 28's complications were enteritis in which blood and mucus were found in the stools. In all three cases the organisms were isolated from the faeces.

(c) Investigation.

An interesting point which has come to light in this investigation is that the average stay in hospital of cases with complications varies with the type.

The following table will bring this out:-

Type		Average Stay in Hospital.
3	.....	63.0 days.
4	.....	59.4 "
6	.....	57.5 "
27	.....	49.9 "
15	.....	47.7 "
1	.....	45.1 "
8	.....	44.7 "
Untyped Strains	.....	44.3 "
2	.....	43.2 "
23	.....	40.2 "
11	.....	34.7 "
28	.....	34.7 "
25	.....	32.5 "

Taking all the complications together we find that the average stay in hospital per case was 52.0 days.

For the period of fifteen months - from September 1st 1937 to November 30th 1938 there were 600 cases who developed complications.

The average stay in hospital for uncomplicated cases was 27.3 days. The difference between the two averages - 52.0 and 27.3 is striking. If we consider that complicated cases stay at least 24 days longer in the wards, then, during the fifteen month period mentioned, the 600 cases with complications were an additional burden to the hospital to the extent of 14,400 days.

(d) Investigation.

During the month of May 1938 there were 131 admissions of scarlet fever cases to the City Fever Hospital. During the same period there were 52 cases who developed complications. The total number of complications were 78, and are as follows:-

Adenitis	 45
Otorrhoea	 13
Rhinitis	 12
Vaginitis	 4
Nephritis	 2
Arthritis	 2

During this period a routine examination of all cases was not being undertaken and only 20 admissions were swabbed, with the following results:-

Patient.	Admitted.	Type.
Nurse Alice Galloway	1/5/38	1
Dorothy Lemon	2/5/38	1
Robert Pollock	5/5/38	2
Nurse Margaret Colville	7/5/38	1
Stewart Gillies	8/5/38	4
William McLean	11/5/38	28
Nancy Millar	12/5/38	1
Robert Hendry	15/5/38	1
Alistair Wilson	16/5/38	1
Agnes Forbes	16/5/38	25
Stella Jack	16/5/38	1
Stewart Dean	18/5/38	0
Neil Lynch	19/5/38	11

Patient.	Admitted.	Type
Helen Millar	22/5/38	1
Jean Eddington	24/5/38	1
Mary Morrison	25/5/38	25
Owen Ward	25/5/38	1
James Scott	25/5/38	0
Margaret Allan	28/5/38	1
Moira Hay	31/5/38	2

Fifteen of the complications were swabbed. The types of haemolytic streptococci found in these cases were as follows:-

Patient.	Admitted.	Complication.	Type of H.S.
1. James McKenzie	11/5/38	Otorrhoea	28
2. Martha McKenzie	12/5/38	Rhinitis	-
3. Molly Skillin	12/5/38	Otorrhoea	28
4. Margaret Millar	15/5/38	Otorrhoea	1
5. Kath. Elms	15/5/38	Otorrhoea	28
6. Alister Wilson	16/5/38	Otorrhoea	28
7. Mary McDougall	19/5/38	Otorrhoea	4
8. Helen Millar	22/5/38	Vaginitis	28
9. Ella Gow	23/5/38	Vaginitis	28
10. Joan Harsburgh	23/5/38	Otorrhoea	4
11. Alice Darrell	27/5/38	Adenitis	28
12. Nurse Agnes Cation	28/5/38	Arthritis of arms	28
13. Lena Topp	28/5/38	Adenitis	0
14. Betty Carter	30/5/38	Adenitis	2
15. Evelyn Alexander	31/5/38	Otorrhoea & Vaginitis.	28

9 of the 14 cases showed type 28 (64.3%)
2 " " " " " " 4
1 " " " " " " 2
1 " " " " " " 1
1 " " " " " an untypable strain.
1 " " " " had a negative throat swab.

Although only a small percentage of the cases with complications were typed, the fact that nine out of the fifteen cases showed complications due to type 28, suggests that the great rise of complications during May was due to an active spread of this type through the scarlet fever wards of the City Hospital.

That one of the cases swabbed had this type on admission suggests that other cases with this type may also have entered hospital. This would account for the spread of complications from this type in several and not only in one of the wards.

The important and interesting question of virulence arises here.

Type 28 had been found thrice in throats on admission during the months of September, October and November 1937. It had also occurred in six complications:-

two cases of adenitis,
one case of arthritis,
three cases of enteritis.

It is difficult to determine how an organism which presented the virulence shown by type 28 during

the May outburst of complications, remained practically non-pathogenic when introduced into hospital some months before. It appears reasonable to assume that its virulence may become attentuated or enhanced depending upon factors outside the scope of this investigation.

It is interesting to note that during the month of May there was a sudden and sporadic outcrop of type 28 cases who entered the hospital. This is observed in the graph designated "Fig.10" which follows page 38.

(e) Investigation (September 1st to November 30th, 1938).

During the three months all admissions were swabbed with three results.

Out of 259 cases 248 gave positive throat swabs. These were classified as follows:

Type	1	60 cases.
"	2	11 "
"	4	110 "
"	6	14 "
"	8	9 "
Untyped	.....	44 "
		248 "

A reversal of these types - 1 and 4 - was the state of affairs during the same period of 1937, as shown below:-

	1937. September, October and November.	1938. September, October, November.
Type 1.	316	60
" 4	28	110

During September, October and November, 1938, there occurred 75 complications in 57 patients, classified as follows:-

Adenitis	24
Rhinitis	19
Otorrhoea	18
Arthritis	3
Vaginitis	1
Nephritis	2
Otitis media ..	2
Pyelitis	1
Relapse	4
	74

On classifying these the following results were obtained:-

No.	Patient.	Age.	Admitted.	Type.	Complication.	Type.	Days in hospital
1.	Jane Dick-	10	3/9/38	1	Otorrhoea	4	36
2.	Mgt.McDougall,	9	13/9/38	2	Otorrhoea Adenitis	4 4	34
3.	Cynthia Swift,	8	17/9/38	4	Early Arthritis Rhinitis	6 4	57
4.	Annie Boyd	6	18/9/38	4	Adenitis	--	45

No.	Patient.	Age.	Admitted.	Type.	Complication.	Type.	Days in hospital
5	Cath.Woodburn,	5	20/9/38	-	Adenitis Rhinitis	4 1	50
6.	Rene Dick	8	21/9/38	0	Adenitis	1	63
7.	Maria Kelly,	5	22/9/38	1	Otorrhoea Adenitis	4 1	45
8.	Georgina Roadnight	7	23/9/38	4	Otorrhoea	1	44
9.	Cath.Clark	8	28/9/38	1	Adenitis	4	42
10.	Jane Dalgleish	5	29/9/38	1	Rhinitis	4	45
11.	Molly Brown	8	29/9/38	4	Early Arthritis	2	27
12.	Marg. Cross	9½	30/9/39	1	Late Otorrhoea	4	93
13.	Harold Brown	1	4/9/38	1	Rhinitis	1	31
14.	Robt.Hutton	5	7/9/38	2	Rhinitis	2	25
15.	Rob.McAndrew	2	9/9/38	-	Rhinitis	6	30
16.	Jean Bottomly	4½	11/9/38	1	Vaginitis	2	28
17.	Alison Salhead,	3	12/9/38	1	Otorrhoea Rhinitis	4 -	55
18.	Jas.McDougall	7	12/9/38	4	Otorrhoea Rhinitis Adenitis	4 - 0	30
19.	Frank McDonald,	2½	14/9/38	4	Adenitis	6	32
20.	Sam. Banks	6	14/9/38	2	Otorrhoea	1	25
21.	Don. Ross	7	15/9/38	-	Otorrhoea	-	52
22.	Joyce Common,	2	16/9/38	1	Otorrhoea Adenitis	1 4	33
23	Derrick Johnstone,	2	17/9/38	8	Rhinitis	22	36
24.	And. Boyd,	8	18/9/38	4	Adenitis	4	35
25.	John Duke	2	18/9/38	0	Rhinitis	4	35
26.	Richard Cardownie,	4	22/9/38	1	Adenitis	4	32
27.	And.Marjoribanks,	2½	26/9/38	1	Late Nephritis Adenitis	1 4	62
28.	Geo. Smith	2	26/9/38	-	Rhinitis	2	27

No.	Patient.	Age.	Admitted.	Type.	Complication.	Type.	Days in hospital
29.	Derrick Falconer,	6	28/9/38	2	Late Nephritis	-	74
30.	David Stuart	9	28/9/38	4	Early Otorrhoea.	4	49
31.	Jean Chambers,	2	28/9/38	1	Rhinitis Relapse	1 -	63
32.	Geo. Proudfoot,	6½	25/9/38	-	Relapse	4	56
33.	Geo. Allan	2	2/10/38	1	Rhinitis	1	59
34.	John McDougall,	1	3/10/38	1	Rhinitis	6	48
35.	Edward Coalfield,	4	7/10/38	4	Adenitis	2	86
36.	Janette Haxton,	4½	11/10/38	1	Relapse	4	43
37.	And.Simpson	4	13/10/38	-	Otorrhoea	4	38
38.	David Robertson,	5	18/10/38	4	Otorrhoea Adenitis Rhinitis	4 1 8	78
39.	John Grant	5	18/10/38	4	Adenitis Rhinitis	- 4	68
40.	Marion McDonald		24/10/38	4	Adenitis	6	27
41.	John Speirs	10	25/10/38	1	Rhinitis	4	33
42.	Graham Scott	5½	28/10/38	1	Otitis Media	4	37
43.	Mona Cassidy	2	28/10/38	1	Otorrhoea Adenitis	4 1	33
44.	Edith Sim	3	29/10/38	4	Adenitis	-	71
45.	Agnes Neyles	7½	1/10/38	-	Adenitis	8	43
46.	Marg.Finlay-	5½	7/10/38	0	Rhinitis	4	33
47.	Lorraine Broen	10	15/10/38	1	Adenitis	1	36
48.	Amy Bruce	5½	25/10/38	1	Adenitis	4	40
49.	Chas.McGinley	4	26/10/38	4	Early Otorrhoea.	8	35
50.	Agnes Hay	10	29/10/38	1	Late Otorrhoea Adenitis	4 1	79
51.	Mary Arthur	6	31/10/38	1	Otitis Media	4	55

No.	Patient.	Age.	Admitted.	Type.	Complication.	Type.	Days in hospital
52	Marjory Harkes,	5	1/11/38	-	Otorrhoea	1	68
53	Evelyn Tait	7½	1/11/38	4	Adenitis	4	78
54	Marg. Mochrie,	8	2/11/38	4	Early Arthritis	4	29
55	Jean Heany	8½	12/11/38	1	Pyelitis	4	39
56	Phyllis Campbell	5½	15/11/38	1	Late Otorrhoea.	4	89
57	Charles Higgin.	6	28/11/38	4	Early Otorrhoea.	4	34

The results of these figures are best represented in tabular form; thus:-

Types of H.S.	Number of cases according to types on admission.		Number of complications due to the various types.	
1	24	(43.1%)	10	(13.3%)
2	4	(7.0%)	7	(9.3%)
4	17	(29.8%)	38	(50.6%)
6	0		5	(6.7%)
8	1		4	(5.3%)
22	0		1	(1.3%)
Untyped	8	(14.8%)	8	(10.6%)
Negative Swabs	3	(5.3%)	2	(2.6%)
Totals	57		75	

In order to compare these results with those obtained from typing the uncomplicated cases, it may be convenient to indicate here what they were:

259 cases were swabbed during the months of September, October and November, 1938. Of these 202 did not produce complications, and were found to fall into the following groups:-

Type 1 H.S.	-	36	cases	(17.9%)
" 2 "	-	7	"	(3.6%)
" 4 "	-	93	"	(46.0%)
" 6 "	-	14	"	(6.9%)
" 8 "	-	8	"	(3.5%)
Untyped "	-	36	"	(17.9%)
Negative Swabs "	-	8	"	(3.5%)
		202	"	

Of the 24 cases which entered hospital with type 1, 15 developed complications which were due to type 4. This indicates that those patients who were admitted with type 1. were particularly liable to contract complications with type 4.

This point appears to be of greater importance than the actual pathogenicity of type 4, since 110 out of 202 cases were admitted with type 4, and 93 of these remained free from complications. The conclusion therefore is that if patients contract scarlet fever from type 4 they are not as likely to get complications from that type, as would be the case if they contract scarlet fever from the less pathogenic type 1 and subsequently become infected with type 4.

In other words it would appear that cases which develop scarlet fever from the more pathogenetic types of haemolytic streptococci, build up an immunity to those types and so decrease the possibility of complications with these more virulent as well as with less virulent strains. It is difficult to find another explanation for the relatively low complication rate among patients of the September-December 1938 epidemic, particularly since it is known that type 4 accounted for almost half the number of admissions.

The fact that more than a third of the cases admitted with type 1 and only 8 out of 110 cases admitted with type 4 contracted complications with type 4, appears strongly in favour of the above assertion.

A further analysis of the complications shows that types 2, 6, 8, 22, and the untyped strains individually accounted for only a small percentage of the total complications.

SECTION 4.

SUMMARY OF PART II.

In the study of the clinical-bacteriological investigation of scarlet fever a number of facts were brought out.

1. Numerous cultural methods for obtaining suitable suspensions of haemolytic streptococci were tried; the best method found was that described on page 26. By the means there mentioned, 93 per cent of cultures gave suitable suspensions for typing purposes. Griffith's slide-agglutination method was used throughout.

2. Of all cases of Scarlet Fever swabbed, 96.6 per cent gave positive swabs.

3. The tables after page 35 show that most of the cases of Scarlet Fever occur during the school age, and almost half the total number of cases occur during the ages 5 to 9.

4. The complications which were encountered in Scarlet Fever were: adenitis, otorrhoea, rhinitis, arthritis, vaginitis, otitis media and mastoiditis, relapse, myositis, local sepsis (peritonsillar abscess, pus in glands, septic fingers, etc.) nephritis, tonsillitis, empyema, sinusitis, pneumonia, endocarditis and peridarditis, and death, in their order of frequency.

5. All cases of Scarlet Fever were swabbed and the positive cases typed, for the periods September 1st 1937 to March 31st 1938, June 1938 and September 1st to November 30th 1938. During the other months, including January 1939, only 20 admissions were typed. In addition to these 20 cases, 15 complications were swabbed in May 1938. In all 1,831 cases of Scarlet Fever were investigated with a view to typing them.

The total number of admissions was 2,169. Of these, 600 developed complications (from September 1st 1937 to November 30th 1938.) 471 of these were investigated.

The results of typing all the positive H.S. Scarlet Fever cases are shown in Figures 7 and 8. The latter figure shows that just over 80 per cent of all the strains obtained were typed.

6. The change in epidemiological strains is given in the charts designated "Figures 9 and 10". It was shown that from September 1937 to April 1938 type 1 was in definite preponderance. After this date type 1 commenced to decrease and type 4 to increase. In July these two types were equal and thereafter, till the conclusion of the investigation, type 4 replaced type 1 as the definite epidemiological strain.

7. In an investigation (page 41) it was shown that in at least 99 per cent of Scarlet Fever cases giving positive swabs, the strains in the nose and the throat were the same.

It was further shown that after a single swabbing only 88.2 per cent of cases gave positive swabs, but that second and third day swabbings brought this total up to 96.6 per cent.

In 2.5 per cent of cases only the nasal was positive.

8. The next investigation (page 44) showed that it is highly probable that a Scarlet Fever case is due to only one type of haemolytic streptococcus.

9. By the investigation which followed (page 48) it was demonstrated that whilst patients were in the wards a considerable amount of cross infection occurred, and that at any one time a single patient may carry a number of types of haemolytic streptococci in the throat.

10. Although more than one type of haemolytic streptococcus were found in the throat of a case at any particular time, it was shown (page 56) that on the first day a complication manifested itself only one type was present and was the aetiological factor.

11. The next investigation (page 62) showed that considerable cross infection occurred among patients

in a single ward; that a new type might be introduced by a patient and rapidly spread through the ward, in some cases giving rise to complications.

A number of facts came to light from this investigation:

(a) The type present on admission tends to persist for an average of nine days before it is temporarily or permanently replaced by another type.

(b) The majority (80 p.c.) of cases become infected with new types, which they carry for varying periods in their naso-pharynx. It was found that before a new type became established, the previous type tended to die out.

(c) Two or three days before a complication becomes manifest the causative type of haemolytic streptococcus is present in the throat. This points to an incubation period.

(d) After three weeks in hospital the number of positive swabs obtained from cases gradually diminishes. Three or more negative swabs may be followed by a positive one.

12. In investigation 6, (page 71), 384 cases showing complications were typed and classified with a view to determining the relationship between types and complications.

It was demonstrated that 61.5 per cent of complications were due to new types, 20.2 per cent due to the same types and 7.5 per cent due to organisms other than haemolytic streptococci.

It was found that more than half of the early complications (up to the fifth day) were due to the original types, and that the later the complications occurred the more likely were they due to new types.

It appears from the next investigation (page 91) that after some four to five weeks in a Scarlet Fever ward the patients build up an immunity to the streptococcus which decreases the possibility of complications and destroys the organisms in the throat, so as to give negative swabs. Apparently the most critical time for complications is just after the second week when an immunity to new strains has not been established and the patients are getting up and thereby becoming exposed to increased cross infection.

13. Of all the types of haemolytic streptococci, type 4 was shown to cause the greatest number of complications.

The types commonly found in the cases of Scarlet Fever were 1, 2, 3 and 4. Type 1 was shown to be the major epidemiological strain during the first half of the investigation. It was also shown not to be very pathogenetic in its production of complications. The reverse was the case with type 4, which in the second half of the investigation became the major epidemiological type.

14. The average stay in hospital was found to be 27.3 days for uncomplicated cases. It was found that

the average stay in hospital of cases complicated with types 3, 4, and 6 was plus-minus 60 days. The average duration of hospital treatment for cases with complications due to the other types was enumerated.

15. During the month of May 1938, type 28 was shown to be a highly pathogenic type of haemolytic streptococcus and probably accounted for the increased complication rate during that month. It was found present in the throats and discharges of 64.3 per cent of complications.

16. From the investigation of all cases from September 1st to November 30th, 1938, it was shown that type 4 accounted for 50.6 per cent of the complications, most of which occurred in patients who entered hospital with other types. The general conclusion was that patients who developed Scarlet Fever from this type were unlikely to develop complications from it.

PART III.

(a) STATISTICAL RECORD OF SCARLET FEVER CASES IN THE CITY OF EDINBURGH.

From September 1st, 1937, to December 31st, 1938, there occurred in the City of Edinburgh 2,287 cases of Scarlet Fever.

2,169 of these were treated in the City Hospital.

118 cases were treated at home, etc.

Of the 2,287 cases 1,364 were school children. The remaining 923 cases were adults and children under five years of age. These 923 cases may be divided into two categories:-

(1) 482 cases came from families in which one or more school-going children had contracted Scarlet Fever. These cases, it may generally be assumed, were due to the same type as those causing the disease in the school-going members.

(2) 441 cases came from families in which there were no children of school age. 263 of these cases were adults and 178 were children below the age of five.

INVESTIGATION I.

The tables following this page indicate the number of patients per month, who came from the various schools and other institutions in Edinburgh, from September 1937 to December 1938.

School.	Sept. 1937	Oct.	Nov.	Dec.	Jan. 1938	Feb.	Mrch.	April.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Pupils Total.	Pupil contacts (cases)
1. Abbey hill.	-	2	6	4	3	2	-	1	2	-	-	-	-	-	-	1	21	8
2. Albion Rd.	-	1	1			1				1		1				1	6	4
3 All Saints.	2					1		2									5	1
4 Allenmuir.																	-	1
5 Balgreen.				2	3	1			2	1	3		1				13	5
6. Bellevue.		2	3					1									6	11
7. Bell's Dr.	7	1			2												10	6
8. Blackhall.		1															1	0
9. Bonnington	5	5			2		2				1		1		1		17	5.
10. Boroughmuir.		1	2	3		1		1			1				1		10	8.
11. Bristo St.			1														1	-
12. Broomfield.	2	4	11	3	1	1	1		2	2	1						28	6.
13. Broughton Elem:	3	7	2	3	3	1		4		2		1			1		27	6.
14. Broughton Sec.		1	1	1	2			1		1							7	2.
15. Burdie House.																	-	2.
16. Cameron House.																1	1	-
17. Canon Mills.	2		2						2			2					8	5
18. Castle Hill.	2	3	1				2	2	1				3				14	7.
19. Clarebank. Special.																	-	1
20. Colinton																	-	2.
21. Corstorphine	2	1	7	2		2	1		1	2	1						19	4.
22. Couper St.	2	7	2	1	1					1	1			2			17	10.
23. Craigentinny	4	5	1	4	1	1		1	3			1			1		22	7.
24. Craiglockhart.	2	1	1	3	2	3	3	2	1	1			3	2	2		26	6.
25. Craigmillar.	12	17	12	3		3	3	4	6	5	2	1		1			69.	21.
26 Crawford Prim.				1													1	-
27. Dalry.	1	2	3	1	2	4	4		2	2	1	1	1	1		3	28	12.
28. Daniel Stewart.	1		1		1	2					1						6	3.
29. Darroch.		1	1	3	2		2	3			1				1		14	3.
30. David Kilpatrick	1		1		1												3	5.
31. Davidsons Mains.												1					1	-
32. Dean.		1	1	1		1											4	-
33. Drummond St.	3		1	1	3		1							1			10	6
34. Duddingston							2								1		3	-
35 Dumbiedykes Nursery.									1								1	-
36. Duncan St. Spec.	1		1											1	1		4	-
37. Edinburgh Acad.						1								1			2	-
38. Edinburgh Ladies Coll.				1			1	1			2		1				6	-
39. Fettes College.			1														1	-
40. Flora Stevenson.	1		1		2	2	4		3	1				1			15	2.
41. George Heriots.			2	1	2	2	2				1			1	1	1	13	4.
42. George Square.					2	2	1				1						6	1.
43. George Watsons.				1	1	2		4			1			1			10	5.
44. Gilmerton.													1				1	-
45. Gillsland.	1								1								2	-
46. Gogarburn.	1																1	-

Schools	Sept. 1937.	Oct.	Nov.	Dec.	Jan. 1938	Feb.	Mrch	Apr'l.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Pupils Total.	Pupil Contacts.
47. Gorgie.		2		3	5			1	2	1		1	1	1	2	2	21	8
48. Hermitage.		4	2	4		1							1		1		13	3
49. Granton.	3	4	4	2				3	2			1		2		1	22	11
50. Holy Cross.			4	3	2	2	1		2				1			3	18	4
51. James Clarks.	1	2					2		1	2		1			1	1	11	9.
52 James Gillespie			7	8	7	2	3	3	7	3	6		5		1	1	53	4.
53 Juniper green.		1									1						2	-
54 Leith Acad.	1	1	5	3	1		3	1	1	2			2	1		1	22	9.
55. Leith walk.		1	1	2	1		2	1	1		1		2		1		13	6.
56. Lettie School.	1																1	-
57. Liberton	2			1													3	-
58. Links	4	6			1												11	6
59. Lochend.	1	3	10	3	2	1	2							1			23	5.
60 London St.	1	1			3			3	1	1	1	1	2				14	8.
61. Longston.											1		4				5	2.
62. Lorne St.		3	2		1				3		1	1	1				12	6.
63 Millon House.	1																1	3.
64. Minto St.																	-	1
65. Moray House.	2		1	1	1	2		1			1		3		1		13	2.
66 New Broughton.																	-	1
67. New Craighall.			10	3													13	6.
68. New Haven.	3	3							1			1					8	2.
69 Niddrie	2	1	1	3	1			3		1			1	2			15	13.
70. North C'Gate.											1					1	2	-
71. North Fort St.	2	5	3	3	2	2	2	1		1		1					22	7.
72. North Merchiston		1	5	2	1			4	6	2		2	1		1	1	26	10.
73. Orwell Place.				1		3				1				1			6	3.
74. Parsons Green.		2	3		1		3	1	1					1			12	1
75. Portobello Sec.		2	2	4	1	2	1	3	2	1		1	1	1	2	3	26	8
76. Prestonfield	2					2	3				1					1	9	4.
77. Preston Lodge.							1										1	-
78. Preston St.	3	3		2	2	1		1		4	1		1		1		19	5.
79. Princess Elizabeth.							1										1	-
80. Queen St.			1				1	4	1								7	2.
81. Roseburn.	1	1	1	8	1		1	1		2			1	3	1		21	6.
82. Royal High		1			1						1	1			1		5	1.
83 Royston.	1	1		1							1						4	8.
84. St. Annes.			1	3	1	1	2	1	3		2		1			1	16	12.
85. St. Anthony.		2		2			1			1				1			7	2.
86. St. Bernard.	1						1										2	6.
87. St. Christopher.		1			1												2	-
88. St. Colmes.	1								2			4	1	1	1		1	-
89. St. Columba.												↓	↓	↓	↓		9	5.
90. St. Cuthbert	2	2	3			2		1			1	1		2	1		15	2.
91 St. Davids.	2	1					1					1					5	2.
92. St. Francis	1		2	1	2				2	2		2	1	2			15	6.
93. St. Ignatius		1		2	3	3	2	1				1	1				14	4

Schools	Sept. 1937	Oct	Nov.	Dec.	Jan 1938	Feb.	March	April	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Publs Total.	Publ Contacts.
94. St. John's.		1		2	2												5	3.
95. St. Margaret's.								1	1					1			3	-
96. St. Mary's	4	2	1	1	3	1	5		2	1	1	1	1	1			24	16.
97. St. Matthew's													1				1	1
98. St. Nicholas													1				1	-
99. St. Patrick's				1	1		1	1	1	1			2				8	2
100 St. Ninians	2		5		2		1						1				11	7.
101. St. Peters.		1	6	5	2	1			1					1			17	2.
102. St. Thomas of Aquinas								1	1					1	2		5	5.
103 Sciennes		1	2	2	1	2			2		1			3	1		15	8.
104 Slateford			1		1												2	1
105. So. Bridge	4		3		1	2	4							1		1	16	6.
106. So. Morningside		1	1	3					1	1		3	3	1	4	2	20	1.
107. Stenhouse	3	10	8	10	2		2				1	1					37	14.
108 Stockbridge	2	1		1			1	1				1	1		1		9	-
109. Toll Cross.	1			1	2	1	4		1			1	1	1			13	11
110 Towerbank.		3	1	3	3	3					2					1	16	6.
111 Trinity Academy.		4	3	2	1	6		2	1			1		8	2		30	6.
112 Tyne Castle.		1	2	5	5	2			1	3			2				21	14.
113 Wardie.				2	1	1	1			1		1			3	2	12	5.
114 Willow Brae											1						1	-
115 Yardhead.		1						1									2	2
116 York Lane.		1			1				1								3	-
Institutions.																		
117. R. H. S. C.	6	1		2	1	3	1	8	6	2		2		1	1	1	35	-
118. R. I. E.	1	1	5	5	6	3	1		5		1						28	-
119 W. G. Hospital.		2	3	1		1	1		1								9	-
120. E. G. Hospital.						1				1							2	-
121. Leith Hospital				1		1	2		2	1							7	-
122. Donaldson Hospital.		2															2	-
123. Crewe Rd. Home.		1	1	3					1		1						7	-
124. Astley Ainsley.								1	2								3	-
125. Elsie Ingles.									1								1	-
All other cases.																		
126.	35	35	44	43	40	34	32	23	34	15	23	8	15	17	19	24	441	-
																Total.	2,284.	
All other Case are:-																		
Children Under 5.	26	25	21	23	19	22	14	16	22	4	17	8	11	14	12	14	263.	
Over 14.	9	10	23	20	21	12	18	7	12	11	6	5	4	3	7	10	178.	

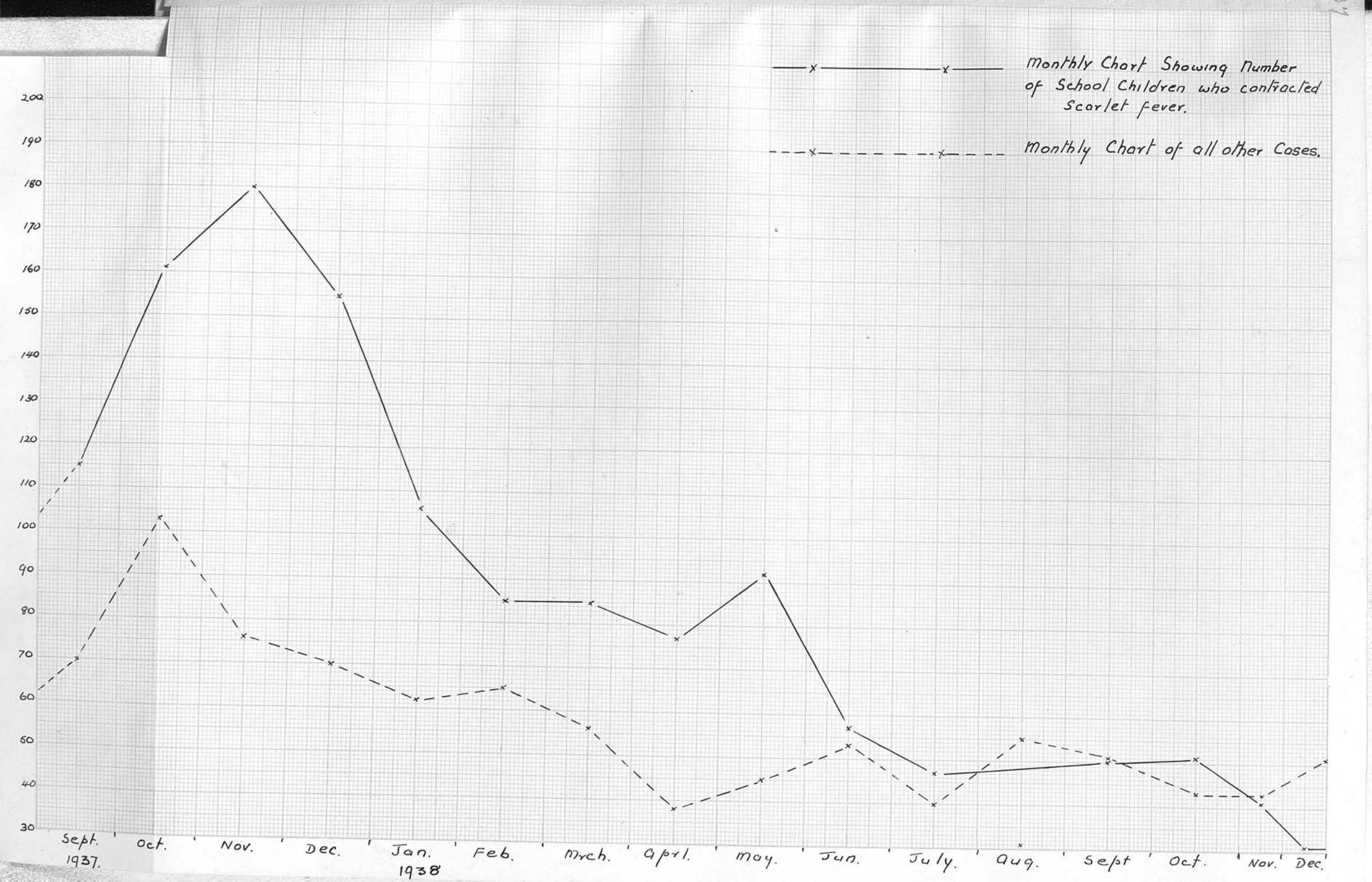
The highest incidence of Scarlet Fever cases occurred during November 1937. After January, 1938, the number fell rapidly and then remained at a more or less steady level until May when another rise occurred. Thereafter there was a progressive fall in numbers until September and November. During November the epidemic was again on the decline, - unlike the conditions during November of the previous year.

The epidemic during the winter months of 1937 was a severe one. It is interesting to note, however, that certain institutions and schools practically escaped the epidemic and only gave rise to an increase in the number of cases during the spring or summer months. As examples of these there were Balgreen, Darroch, George Heriots, George Square, George Watsons, London Street, Queen Street, R.H.S.C., St.Annes, Tollcross, Leith Hospital, and the Astley Ainsley Institute. This fact will be best studied from the previous tables.

Following this page is given a graph showing the monthly increase of school cases as compared with all others.

The schools and institutions which yielded the greatest number of cases are the following:-

Craigmillar	69	James Gillespie	53
Stenhouse	37	Royal Hosp.for Sick Ch...	35
Trinity Academy	30	Broomfield	28


Monthly Chart Showing Number of School Children who contracted Scarlet fever.
Monthly Chart of all other Cases.
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
Sept. 1937.
Oct.
Nov.
Dec.
Jan. 1938
Feb.
Mrch.
Aprl.
May.
Jun.
July.
Aug.
Sept
Oct.
Nov.
Dec.

Dalry	28	Broughton Elementary ..	27
Craiglockhart	26	North Merchiston	26
Portobello Secondary	26	St. Mary's	24
Lochend	23	Craigentinny	22
Granton	22	Leith Academy	22
North Fort Street ..	22	Abbeyhill	21
Gorgie	21	Roseburn	21
Tynecastle	21	South Morningside	20
Corstorphine	19	Preston Street	19
Holy Cross	18	Bonnington	17
Couper Street	17	St. Peters	17

R.I.E. 28

These 29 schools and institutions accounted for 759 of the 1,364 cases in school children. The rest of the cases - 605 - came from the other 96 schools and institutions in Edinburgh.

When we consider these schools we find the interesting fact that in those which showed relatively a large number of cases during September, October, November and December of 1937, showed a correspondingly low number of cases during the same period of 1938. On the other hand where the numbers were low in 1937 they showed high numbers in 1938, relative to the total numbers of admissions. Thus:-

	School.	Cases during Sept. to Dec. 1937.	Cases during Sept. to Dec. 1938.	Total No. of Cases Sep.'37 - Dec.1938.
i.	Craigmillar	44	1	69
	Stenhouse	31	0	37
	Broomfield	20	0	28
	Broughton Elementary	15	1	26
ii.	James Gillespie	15	7	53
	Trinity Academy	9	10	30
	Dalry	7	5	28

From Group i. it appears that when a school is struck with a heavy epidemic of Scarlet Fever, it may expect only a few cases during the same period of the following year.

Group ii. indicates that where the number of cases relative to the total number of admissions is low (viz. 15 : 53; 9:30; 7 : 28) during a period of one year, a similar or greater number of cases may be expected during the same time the following year.

What relation these figures bear to the total number of pupils, - susceptibles and immunes, is a problem beyond the scope of this enquiry.

A monthly classification of the various patients dealt with in this investigation is as follows (the figures in brackets indicate those cases who were treated in the City Hospital):-

Month.	No.of Pupils.	No. of Cases - Pupil Contacts.	No. of Cases - Source of Infection unknown.
1937.			
Sept.	115 (113)	35 (30)	35 (34)
Oct.	161 (157)	68 (63)	35 (34)
Nov.	180 (176)	32 (30)	44 (42)
Dec.	155 (152)	27 (24)	43 (41)
1938.			
Jan.	106 (104)	22 (18)	40 (38)
Feb.	85 (82	31 (30	34 (30)
Mar.	85 (82)	24 (22)	32 (29)
Apr.	77 (76)	15 (14)	23 (21)
May.	92 (90)	11 (10)	34 (31)
June	57 (53)	38 (35)	15 (13)
July	47 (45)	17 (17)	23 (21)
Aug.	31 (30)	47 (41)	8 (7)
Sep.	50 (46)	36 (33)	15 (15)
Oct.	51 (49)	28 (26)	17 (14)
Nov.	41 (37)	24 (21)	19 (18)
Dec.	31 (28)	27 (25)	24 (22)
	1364 (1320)	482 (439)	441 (410)

I N V E S T I G A T I O N II.

The previous classification is carried out further and shows the numbers of all the types of haemolytic streptococci found in the various groups of patients. (The figures in brackets here refer to the number of patients who gave positive swabs.)

September 1937.

Scholars.	Patients who were scholar contacts.	Patients with sources of infection unknown
113 (100)	30 (25)	34 (29)
Type 1. 30	11	6
" 2. 10	0	0
" 3. 0	0	1
" 4. 16	3	0
" 6. 0	0	3
" 8 8	2	0
" 11 2	3	0
" 15 4	1	3
" 22 0	0	3
" 25 0	0	2
" 27 0	0	2
" 28 1	0	0
Untyped 29	5	9
100	25	29

October 1937.

	Scholars.	Patients who were scholar contacts.	Patients with sources of infection unknown.
	157 (135)	63 (53)	34 (27)
Type 1	88	30	8
" 2	7	6	0
" 3	0	2	2
" 4	3	2	2
" 6	0	0	1
" 8	5	1	0
" 11	4	0	0
" 15	5	0	0
" 18	0	0	0
" 22	0	0	1
" 25	2	0	1
" 27	0	1	2
" 28	0	0	1
Untyped	21	11	9
	135	53	27

November 1937.

	176 (154)	30 (23)	42 (34)
Type 1	110	13	20
" 2	15	2	2
" " 3	0	2	3
" 8	3	0	0
" 23	2	0	0
" 25	0	0	1
" 27	0	0	1
" 28	0	1	0
Untyped	22	5	7
Totals	154	23	34

December 1937.

Scholars.		Patients who were scholar contacts.	Patients with sources of infection unknown.
152 (148)		24 (22)	41 (39)
Type 1	88	8	11
" 2	12	3	4
" 3	6	1	8
" 4	10	4	2
" 6	0	0	2
" 8	4	0	3
" 11	4	0	0
" 27	0	0	1
Untyped	24	6	8
	148	22	39

January 1938.

104 (100)		18 (17)	38 (37)
Type 1	68	7	23
" 2	10	2	1
" 3	1	3	6
" 4	2	1	0
" 8	2	0	0
Untyped	17	4	7
	100	17	37

February 1938.

Scholars.	Patients who were scholar contacts.	Patients with sources of infection unknown.
82 (79)	30 (29)	30 (29)
Type 1 57	15	18
" 2 10	1	2
" 3 0	3	5
" 4 0	0	1
" 8 1	0	0
" 11 1	0	0
" 27 0	1	0
Untyped 10	9	3
Totals 79	29	29

March 1938.

82 (79)	22 (22)	29 (28)
Type 1 49	12	15
" 2 10	5	1
" 3 4	2	6
Untyped 16	3	6
Totals 79	22	28

June 1938.

53 (50)	35 (33)	13 (13)
Type 1 16	17	6
" 2 14	6	0
" 3 0	0	1
" 4 11	5	0
" 11 1	0	0
" 25 0	0	3
Untyped 8	5	3
Totals 50	33	13

September 1938.

Scholars.	Patients who were scholar contacts.	Patients with sources of infection unknown.
46 (44)	33 (31)	15 (14)
Type 1 16	13	3
" 2 6	0	0
" 4 14	10	3
" 6 0	0	3
" 8 0	1	1
Untyped 8	7	4
Totals 44	31	14

October 1938.

49 (46)	26 (25)	14 (14)
Type 1 6	8	4
" 2 3	1	0
" 4 27	10	3
" 6 2	1	4
" 8 0	2	1
Untyped 8	3	2
Totals 46	25	14

November 1938.

37 (36)	21 (21)	18 (17)
Type 1 0	4	6
" 2 1	0	0
" 4 29	9	5
" 6 1	0	3
" 8 0	4	0
Untyped 5	4	3
Totals 36	21	17

A number of things may be observed in these tables:-

Certain types tend to predominate in the scholar cases: these are 2, 4, 8, 11, 15. This is well illustrated in the tables for the months September to December 1937 and January to March 1938.

There is a certain similarity between the strains found in the scholar cases and those cases who were in contact with them.

The majority of new and sporadic types belong to that group of patients who had not been living with school children. This is particularly noticeable with regard to types 3, 6, 22, 25 and 27 during the months of September to December 1937.

Type 1. is fairly evenly distributed among the three groups of patients.

When all the tables are considered together the general conclusion is that, during an epidemic, such as occurred in the winter months of 1937, there is mainly one predominant type of haemolytic streptococcus which accounts for the majority of cases. This strain spreads throughout the community. The lesser strains, as will be more fully shown later in this work, are sporadic in their occurrence and tend to remain restricted to certain sections of the community.

This community may roughly be divided into two classes - one consisting of school children to which they belong, the other consisting of families in which

there are no school-going members. It must be pointed out that this division is very rough and by no means definite. Social intercourse in an urban community, such as Edinburgh possesses, must necessarily occur. The figures in the tables are, however, sufficiently definite to indicate that such a division is permissable.

I N V E S T I G A T I O N III.

This investigation concerns only school children who contracted Scarlet Fever. An attempt is made to show that a relationship existed between H.S. types and the various schools.

Schools. (Only a selected number)	Months --- Showing the number of typed cases for each month. (The total number of cases for each month is given in brackets). The typed cases are further subdivided and the number of cases for ~~for~~ each type (in red - thus T25-8) is given.						
	Sep.'37	Oct.'37	Nov.'37	Dec.'37	Jan.'38	Feb.'38	Mch.'38
1. Abbeyhill.	-	2 (2) T2-2	5 (6) T2-4 T1-1	2 (4) T2-2	3 (3) T2-3	1 (2) T1-2	-
2. Bonnington.	4 (5) T1-4	5 (5) T1-5	-	-	1 (2) T2-1	-	-
3. Broomfield.	2 (2) T1-2	4 (4) T1-4	9 (11) T1-8 T8-1	2 (3) T8-2	1 (1) T8-1	1 (1) T1-1	1 (1) T1-1
4. Broughton Elementary.	2 (3) T1-2 T4-1	6 (7) T1-4 T4-2	2 (2) T1-1	3 (3) T1-3	2 (3) T1-3	1 (1) T?-1	-
5. Craigmillar.	10 (12) T1-7 T?-5	16 (17) T1-10 T?-7	10 (12) T1-1 T?-9	2 (3) T?-2	-	3 (3) T2-3	3 (3) T2-3
6. Drummond Street.	3 (3) T4-3	-	1 (1) T1-1	(1)	3 (3) T1-3	-	1 (1) T3-1
7. Gorgie.	-	2 (2) T25-2	-	2 (3) T1-2	5 (5) T1-5	-	-
8. James Gillespie.	-	-	6 (7) T2-6	7 (8) T1-1 T2-6	7 (7) T1-5 T2-2	2 (2) T1-2	2 (3) T1-2
9. Leith Acadamy	1 (1) T8-1	1 (1) T8-1	4 (5) T1-2 T8-2	3 (3) T1-2 T8-1	-	2 (3) T1-3	1 (1) T1-1
10. Links.	4 (4) T15-4	5 (6) T15-5	-	-	1 (1) T1-1	-	-
11. Lochend.	1 (1) T1-1	2 (3) T1-2	7 (10) T1-7	3 (3) T1-3	1 (2) T1-1	1 (1) T1-1	2 (2) T1-2
12. North Fort Street.	2 (2) T11-2	4 (5) T11-4	3 (3) T1-3	2 (3) T1-2	2 (2) T1-2	1 (2) T1-1	1 (1) T1-1
13. St. Mary's	4 (4)	2 (2)	- (1)	1 (1)	3 (3)	1 (1)	4 (5)

From the few selected schools a number of interesting facts will be observed:

(1) The great majority of cases occurring at any particular time are due to the same type; e.g.:

School No. 2 - September and October. Type 1
" No. 6 - September. " 4
" No.10 - September and October. " 15
" No.13 - September. " 4

(2) The same types tend to persist in the same schools; thus type 2 accounted for 12 of the 13 typed cases which occurred in Abbeyhill; type 1 accounted for 9 out of 10 cases in Bonnington.

(3) In certain schools two types may run concurrently, but in the majority of cases the one type dies out to leave the other type to cause all the cases.

This point is well illustrated in the case of Leith Academy; Type 8 caused two cases during September and October. In November type 1 was introduced into the school and accounted for one case, whereas type 8 produced two cases. The next month type 1 produced two cases and type 8 only one. After this type 8 disappeared and type 1 produced four other cases. Another school which illustrates this point is James Gillespie.

(4) Links School is interesting in that all nine cases which were typed proved to be type 15. It appears that this temporarily exhausted the susceptibles for no other case occurred till three months later when type 1 accounted for one case.

(b) SUMMARY.

(1) Of 2,287 cases of Scarlet Fever 2,169 were treated in the City Hospital.

(2) Of the 2,287 cases 1,364 were school children.

(3) 1937 was an epidemic year of some severity. The highest incidence of Scarlet Fever occurred during October, November and December of that year. 1938 showed relatively month for month far fewer cases.

(4) Certain schools which showed a high percentage of cases during the winter months of 1937 had a low percentage of cases during 1938. Those schools with a lower percentage during 1937 had a relatively high percentage in 1938.

(5) Scarlet Fever cases may roughly be divided into two classes: (a) school children and other members of their families; (b) Adults and infants who are non-members of any institutions and are not in contact with school children.

(6) The strains of haemolytic streptococci causing Scarlet Fever may vary in these two broad classes, but the epidemiological strain or strains are common to both.

(7) In certain schools certain strains of haemolytic streptococci predominate whether they be the epidemiological strains or not.

(8) When two or more strains occur concurrently in a school, one predominates eventually and accounts for most of the cases.

P A R T IV.

HAEMOLYTIC STREPTOCOCCI FROM SOURCES OTHER THAN SCARLET FEVER.

SECTION 1.

(a) Swabs from Pathological Cases.

I N V E S T I G A T I O N I.

Puerperal Fever.

From October 2nd, 1937 to November 11th, 1938, the following 54 cases of puerperal fever were investigated:

	Patient.	Age.	Address.	Admitted & Discharged.
1	Winnie Edgar	24	49 Balbirnie Place	2/10/37 23/10/37
2	Christina Gibb	42	1 Church St. Inner-leithen.	4/10/37 6/11/37
3	Mary Smith	43	4/1 Corporation Blds, Leith. DIED	5/10/37 12/10/37
4	Elizabeth Hall,	29	2 Beechbank, Harthill, DIED	7/10/37 7/10/37
5	Isa. Braid-wood,	29	60 Craigcrook Av., Black-hall. DIED	8/10/37 23/11/37
6	Mary Lewis	30	18 Harewood Road	11/10/37 30/10/37
7	Adelia Wilson	33	2 Polton Hall, Bonnyrigg.	21/10/37 13/11/37
8	Eliz.Gibson	27	32 Buchanan Street,	22/10/37 9/11/37
9	Marg.Blythe	24	Veitch's Bldgs., Burdiehouse	26/10/37 4/12/37

	Patient.	Age.	Address.	Admitted & Discharged.
10	Isa. Burgoyne,	21	58 Lammermuir Cres. Dunbar.	10/11/37 27/12/37
11	Mary Drummond	26	38 West Bowling Green Str.	14/11/37 30/11/37
12	Mary Crockett	38	5 Narewood Road	21/11/37 14/12/37
13	Jane Bryce	22	36 Whiteside, Bathgate	25/11/37 21/12/37
14	Marg.Williamson	25	113 Bonnington Rd. Leith	25/11/37 21/12/37
15	Mary Brogan	18	60 Eskside, Musselburgh.	4/12/37 29/1/38
16	Ellen Davidson	36	19 Eskdale St. Dalkeith	9/12/37 2/1/38
17	Christina Hare	37	95 Restalrig Road,	14/12/37 28/12/37
18	Jane Ward	31	28 Louisa Square, Rosewell	1/1/38 16/1/38
19	Mary Skilly	28	389 Easter Road	2/1/38 23/1/38
20	Emmla Scott	22	Queen Mary Nursing Home.	2/1/38 12/2/38
21	May Wright	24	184 High Street Dalkeith	3/1/38 7/1/38
22	Annie Urquhart	19	96 Leith Street	18/1/38 1/2/38
23	Eliz. O'Brien	22	9 Schan Rd. Prestonpans,	21/1/38 15/3/38
24	Nina Connell	19	Cowdenhill House, Boness. DIED	26/1/38 4/2/38
25	Hannock Hirling	35	11 Lothian Cres. Boness	5/2/38 5/3/38
26	Muriel Duff	42	27 Dundas Street	14/2/38 1/3/38
27	Helen Marshall	36	6 Chalmers Blds.,	18/2/38 11/3/38
28	Georgina Green-	18	11 Portland Ter. Fauldhouse	21/2/38 2/5/38
29	Jean Grieve	18	16 Buchanan Street	1/3/38 19/3/38
30	Marg. Duncan	34	Royal Terrace, Linlithgow	4/3/38 18/3/38
31	Sarah Moonie	39	45 Polton Gdns, Lasswade	8/3/38 9/3/38

	Patient.	Age.	Address.	Admitted & Discharged.
32	Marg.Gellison	22	9 Rosemount, Bathgate	26/3/38 5/4/38
33	Agnes Halliday	23	Islay House, Pencaitland	25/3/38 27/3/38
34	Alice Bell	28	118 Easton Row, Bathgate	26/3/38 5/4/38
35	Margaret Runell	18	29 Brunswick Road,	30/3/38 12/4/38
36	May Ormiston	31	The Gardens, Hopetown	12/4/38 22/3/38
37	Mary Young	25	West End, Birghan, Kelso	16/4/38 6/5/38
38	Catherine Aitken	32	75 Bilston, Roslin	25/4/38 14/ 5/38
39	Barbara Kinnaird	32	42 Sleigh Drive	14/5/38 31/5/38
40	Christina King	25	13 Inveresk Rd. Musselburgh (R.M.H.)	23/5/38 17/6/38
41	Mary Paton	26	68 Greendykes Rd., Broxburn (R.M.H.)	15/6/38 9/7/38
42	Margaret Smith	19	24 Clearburn Gardens (R.M.H.) DIED	23/6/38 27/6/38
43	Catharine Lawson	24	4 Braid Place	24/7/38 13/8/38
44	Rosina Watson	20	"Redhughes", Corstorphine, (R.M.H.)	28/7/38 9/8/38
45	Helene McDonald	37	46 Arden Street	5/8/38 9/9/38
46	Cecilia Wood	28	4 Southfield Gardens East,	14/8/38 3/9/38
47	Mary Armstrong	35	61 Whitecraigs Road, Musselburgh.	25/9/38 21/10/38
48	Margaret Wishart	22	18 Crillesthene Cres.	20/10/38 22/11/38
49	Agnes Cain	29	24 Newtown, Boness	13/10/38 8/11/38
50	Jane Cooper	40	4 Deanfield Cres. Boness	16/10/38 1/11/38
51	Jemima Glaysher	30	18 Morrison Gdns, South Queensferry,	5/11/38 3/12/38
52	Jessie Mitchell	25	4 Ingliston Street	10/11/38 29/11/38
53	Christina Wood	32	The Crescent, Newton grange,	25/11/38 31/12/38
54	Violet Ferguson	22	26 Baltic St. Leith	25/11/38 17/12/38

In all the above cases swabs from the throat and the genital tract were taken. In a few cases blood cultures were also made.

The object of this investigation was not to study puerperal fever, but to ascertain what types of haemolytic streptococci were present in these cases and find what relationship they bore to the types found in Scarlet Fever.

24 of the puerperal cases were resident outside Edinburgh. A number of these were, however, delivered in Edinburgh. It is difficult to determine whether the last mentioned group was infected in the City, and so formed part of the epidemic of streptococcal infections, or whether they brought the types of organism with them from the country districts.

Of the 54 cases, 14 gave negative swabs by ordinary aerobic plate methods.

All swabs were kept for 24 hours and those which proved negative were again plated out on blood-agar and placed in an anaerobic jar. By such methods two more swabs were shown to be positive. This left twelve cases which presumably had no haemolytic streptococci in their throats or genital tracts. Two of these swabs gave almost pure cultures of B. coli and one of a staphylococcoform organism which could not be classified.

The 42 cases which gave positive swabs may be divided thus:-

In 22 cases cervical swabs alone were positive.

In 9 cases throat swabs alone were positive.

In 7 cases both throat and cervical were positive.

In 2 cases the blood and cervical were positive.

In 1 case the blood alone was positive.

In 1 case with mastitis the breast gave a positive swab.

Only five blood cultures were made. These were from cases 3, 4, 5, 14, 42. The severest cases were chosen for the purpose. Of these five cases four eventually died. In case 5 type 15 was found both in the blood and cervix. Case 42 gave an untypable strain from both sources.

Of the seven cases which gave positive swabs from the throat and cervix two had the same type (cases 1 and 54); two had unclassified types (cases 22 and 45), and three had different types in both parts of the body.

The following table indicates the results of typing:-

No.	Cervix.	Throat.	Blood
1.	1	1	
2.		Negative	
3.	4		
4.	3		
5.	15		15
6.		Negative	
7.	1		
8.		1	
9.	?		
10.	?		
11.		6	
12.	1	2	
13.		13	
14.	Negative		
15.	1	?	
16.	?		
17.	Negative		
18.	?		
19.	Negative		
20.	Negative		
21.	?		
22.	?	?	
23.		3	
24.	1		
25.	13	1	
26.	?		
27.	?		

No.	Cervix.	Throat.	Blood.	Breast.
28.	25			
29.	?			
30.		13		
31.				1
32.		?		
33.		Negative		
34.		13		
35.	?			
36.	Negative			
37.	?			
38.	28			
39.	Negative			
40.	28			
41.	27			(anaerobic culture)
42.	?		?	
43.	?			
44.	Negative			
45.	?	?		
46.		?		
47.	Negative			
48.	Negative			
49.	6			
50.	?			
51.		4		
52.	6			
53.	?			
54.	4			

Except for type 13 all the other types were present in Scarlet Fever.

When these types are compared in the two diseases it becomes evident that the relative increase and decrease of the various types bear a certain relationship to each other.

Thus during the early part of the investigation, from October 1937 to January 1938, seven of the twenty-five typed strains belonged to type 1. This period corresponded with the high incidence of type 1 in Scarlet Fever. (Vide Fig.9). After March type 1 no longer appeared in the puerperal cases examined.

The next most striking fact is the sudden outburst of type 4 cases in November 1938 which corresponds to the September-December epidemic of type 4 Scarlet Fever.

Another fact worthy of attention is the sudden appearance in May 1938 of two puerperal cases in which type 28 occurred. May was the time when a sporadic increase of Scarlet Fever occurred, due to type 28 (Vide Fig.10). It was shown in a previous section of this work that this type was responsible for a high percentage of complications in Scarlet Fever.

The appearance of type 6 in October 1938 likewise corresponds with a similar increase of that type in Scarlet Fever cases.

Whether these observations are merely a matter of chance is not possible to tell from the limited

number of cases investigated. The main feature however remains, namely, that the reversal of types 1 and 4 as the major epidemiological strains in Scarlet Fever corresponded to a similar reversal of types in the case of puerperal infection.

I N V E S T I G A T I O N II.

ERYSIPELAS.

The object of this investigation, as in the previous one, was to ascertain whether there existed any relationship between the types of haemolytic streptococci found in these conditions.

The following cases of erysipelas were examined with this object in view:

(Early in the investigation only those patients who showed broken skin over the erysipelatous lesions were swabbed. This method gave positive results in a large proportion of cases where the skin had recently broken down. In those cases where this had occurred for some time the percentage of positive swabs obtained was very much lower. A new method was therefore adopted: With an intradermal needle and hypodermic syringe a small bleb at the spreading margin of the lesion was punctured. A small quantity of fluid was withdrawn and directly inoculated on to a blood-agar

plate. This was subsequently stroked out and incubated. This method proved more satisfactory than the cruder method employed at first, which precluded the choice of those cases that appeared interesting from the point of view of this investigation.)

No.	Patient.	Age.	Address.	Admitted & Discharged.
1.	Janet Drummond	71	2 London Road	18/12/37 4/1/38
2.	Agnes Symington,	34	4 Merchiston Place	21/12/37 1/1/38
3.	Agnes Bennett	56	46 Jordan Lane,	24/12/37 8/1/38
4.	John Casson	10	11 Warrender Park Terrace,	8/1/38 22/1/38
5.	Margaret Kelly	53	Wardieburn Pl. West	14/1/38 25/1/38
6.	James Lynch	33	Astley Ainsley Institute.	22/1/38 1/2/38
7.	John Knight	23	74 Redford Avenue	24/1/38 4/2/38
8.	Jessie Ogilvie	44	86 Westbow, George IV Bridge	8/2/38 19/2/38
9.	Charles Bryce	73	Eastern General Hospital	11/2/38 1/3/38
10.	Isa. Anderson	63	Craiglockhart Institute	25/2/38 5/3/38
11.	Chas. O'Neil	46	5 Gilchrist's Entry	1/3/38 8/3/38
12.	Violet Harper	4	97 Abbeyhill	6/3/38 12/3/38
13.	Nora Hain	57	17 Pirniefield Place	10/3/38 19/3/38
14.	Mary McKenzie	50	16 Springfield Street, Leith	20/3/38
15.	Mary Newell	75	37 Niddrie Mains Drive	24/3/38 2/4/38
16.	Jessie Craig	75	71 Bangor Road	29/3/38 16/4/38
17.	Catherina Craik	3	4 Main Street, Newhaven	6/4/38 30/4/38

No.	Patient.	Age.	Address.	Admitted & Discharged.
18.	Janet Maloy	28	24 Guthrie Street	6/5/38 17/5/38
19.	Annie McFarlane	18	Nurses Home, R.H.S.C.	8/5/38 21/5/38
20.	James Lawrie	36	9 Goganlea Gardens	16/5/38 17/5/38
21.	Euphemia Dye	42	22 Bellfield Cres. Kirkcaldy	24/5/38 31/5/38
22.	Jean Swan	48	15 Beggs Buildings	3/6/38 13/6/38
23.	John Taylor	40	12 Corporation Bldgs. McLeod Street.	23/6/38 29/6/38
24.	Johan Mitchell	39	16 Hay Drive	13/6/38 2/7/38
25.	Ebenezer Logan	41	4 Corstorphine Bank Cotts.	6/7/38 23/7/38
26.	James Gribben	31	1 Pleasance	27/7/38 1/8/38
27.	Annie Wood	49	6a Royal Circus	31/7/38 20/8/38
28.	Edward Newcombe	15	66 Longstone Road	13/8/38 23/8/38
29.	Eliz. Martin	4½	14 Stenhouse Av. West	24/8/38 6/9/38
30.	Thomas Glass	42	2 Gillespie Street	31/8/38 13/9/38
31.	Margaret Wilson	61	11 Muir Terrace, Stoneyburn	18/9/38 29/9/38
32.	James Welsten	56	1 Orwell Place	23/9/38 1/10/38
33.	Cath.McDonald	18	Nurses Home, City Hosp.	23/9/38 3/10/38
34.	Chris. Pearson	52	68 Lorne Str. Leith	27/9/38 8/10/38
35.	Rob. Alexander	38	47 Peffermill Road	4/10/38 15/10/38
36.	George Dow	57	1 Whitson Way	9/10/38 18/10/38
37.	Chas. O'Neil	46	Gilchrists Entry	17/10/38 25/10/38

No.	Patient.	Age.	Address.	Admitted & Discharged.
38.	Helen Dickson	42	4 Roseburn Crescent	10/11/38 26/11/38
39.	Thomas McSorley	47	326 Leith Walk	30/11/38 13/12/38
40.	Alexander Banks	63	129 St.Leonards Street	17/12/38 31/12/38

Forty cases of erysipelas were examined over a period of twelve months, from December 1937 to December 1938. They were typed as follows:-

Patient.	Month.	Year	Throat Type.	Lesion Type.
No. 1	Dec.	1937	1	-
2	"	"	0	1
3	"	"	0	0
4	Jany.	1938	1	1
5	"	"	0	1
6	"	"	0	2
7	"	"	3	3
8	Feb.	"	0	1
9	"	"	0	25
10	"	"	0	0
11	Mch.	"	7	7
12	"	"	1	1
13	"	"	0	2
14	"	"	0	7
15	"	"	-	30 ?
16	"	"	0	-
17	April	"	0	1
18	May	"	0	7
19	"	"	1	1
20	"	"	28	28
21	"	"	1	0
22	June	"	-	-
23	"	"	0	25
24	"	"	0	2
25	July	"	0	7
26	"	"	-	--
27	"	"	-	-
28	Aug.	"	4	4
29	"	"	25	25
30	"	"	1	-
31	Sep.	"	0	3
32	"	"	0	7
33	"	"	0	-
34	"	"	0	-

Patient.	Month.	Year.	Throat type.	Lesion type.
No. 35	Octr.	1938	4	4
36	"	"	0	-
37	"	"	7	7
38	Novr.	"	0	0
39	"	"	-	-
40	Decr.	"	4	4

It is observed that the strains 1, 2, 3, 4, 7, 25, 28 and 30 were encountered.

In three cases the throat swabs showed a different type to that found in the lesion (cases 1, 15 and 30).

In ten cases the throat harboured the same type as that found in the lesion.

Four cases failed to give haemolytic streptococci from the lesions. Twenty of the throat swabs were negative.

Eleven of the lesion strains could not be typed.

During December 1937 to March 1938 five out of twelve cases were due to type 1. Type 4 appears for the first time in October. The second case due to this type occurred in December. This finding is in accordance with that observed in Scarlet Fever and puerperal infection.

One case with type 28 occurred in May.

Type 7 is six times met with. This type was not found in Scarlet Fever.

It is seen that of the seven cases below the age of 20, not one carried type 7. With one exception (case 29) all these younger patients were infected with the common epidemiological types 1 and 4. The older patients alone introduced the types 7, 25 and 28.

From this brief investigation it appears that young patients get erysipelas from the common epidemio-logical strains, whilst a large proportion of cases among older people is produced by non-epidemiological strains.

Numbers 11 and 37 are the same case. Charles O'Neil was re-admitted more than seven months after discharge, and in both instances his erysipelas was due to type 7. Furthermore he carried the same type in his throat.

I N V E S T I G A T I O N III.

OTITIS MEDIA and MASTOIDITIS.

Ten cases of otitis media with discharges were swabbed in the wards of the Ear, Nose and Throat Department of the Royal Infirmary during the month of September 1938.

Six of the cases were children under the age of ten. Four cases were adults.

Three of the six cases and one of the four cases were due to haemolytic streptococci. These were typed as follows:-

(The names of the patients were not recorded.)

Number	Ear	Throat.
1.	0	0
2.	0	0
3. Mastoiditis & Otorrhoea	1	0 (7 years)
4.	0	0
5. Otitis Media and Otorrhoea.	4	4 (3½ years)
6. Mastoiditis & Otorrhoea	4	0 (10 years)
7.	0	0
8.	0	0
9. Otitis Media and Otorrhoea.	14	14 (adult)
10.	0	0

The types corresponded, with the exception of type 14, to the epidemiological strains prevailing at the time.

I N V E S T I G A T I O N IV.

TONSILLITIS.

The following cases of tonsillitis were investigated in the City Fever Hospital:-

No.	Patient.	Age.	Type of H.S.	Admitted.	Discharged
1.	Mary Duffy	16	1	9/1/38	25/1/38
2.	Nurse Mary Morrison,	18	3	7/2/38	26/2/38
3.	Nurse Jean Dingwall	18	0	6/3/38	22/3/38
4.	Margaret Muir	61	1	23/3/38	19/4/38
5.	Alex. Patterson	15	0	5/4/38	26/4/38
6.	Sheila Foulis	4	1	30/4/38	7/5/38
7.	Mina Oliver	12	-	29/4/38	10/5/38
8.	Margaret Weir	23	2	4/5/38	14/5/38
9.	Agnes Kyles	8	0	5/5/38	17/5/38
10.	Jas. Morrison	17	-	6/5/38	14/5/38
11.	Stewart Gillies	15	28	8/5/38	17/5/38
12.	Bernard Keran	7	1	14/5/38	7/6/38
13.	Molly Reilly	14	0	15/5/38	4/6/38
14.	Marg. Grieve	13	0	1/6/38	18/6/38
15.	Thomas Boyter	9	0	9/6/38	18/6/38
16.	Sarah Smith	50	11	14/6/38	28/6/38
17.	Anna McRae	3	-	24/6/38	9/7/38
18.	Rod. Burnett	5	1	24/6/38	16/7/38
19.	Jas.Williamson	6	0	26/6/38	26/7/38
20.	Mary Murphy	2½	1	14/7/38	2/8/38
21.	John Allan	29	0	25/7/38	27/7/38
22.	Rob. Johnstone	4½	1	28/7/38	9/8/38

No.	Patient	Age.	Type of H.S.	Admitted.	Discharged.
23.	Christina Scott	5	1	7/8/38	27/8/38
24.	Lawrence Gilroy	3	-	8/8/38	13/8/38
25.	Isa Fleming	15	2	28/8/38	10/9/38
26.	Donald Kerr	8	18	22/9/38	4/10/38
27.	Douglas Nisbet	5	4	20/9/38	1/10/38
28.	Annie McCabe	13	0	24/9/38	4/10/38
29.	Hazel Waters	3	0	28/9/38	18/10/38
30.	Annie Young	14	2	30/9/38	18/10/38
31.	Sheila Dufton	5	0	1/10/38	1/11/38
32.	Kenneth McLeod	1	4	2/10/38	15/10/38
33.	Edward Burston	10	4	2/10/38	15/10/38
34.	Mary Wood	6	3	3/10/38	5/11/38
35.	Patrick Rafferty	6	1	8/10/38	28/10/38
36.	Agnes Ogilvie	6	0	9/10/38	22/10/38
37.	Wilfred Newborn	7	5	11/10/38	22/10/38
38.	Annie McKenzie	9	1	11/10/38	1/11/38
39.	Andrew Simpson (Otitis Media on 5th day.)	4	4	13/10/38	19/11/38
40.	Douglas Brown	4½	0	16/10/38	29/10/38
41.	Oliver Campbell	8	6	18/10/38	12/11/38
42.	Marg. Cunningham (Adenitis)	9	4 (4)	26/10/38	15/11/38
43.	John Forest	8	0	26/10/38	12/11/38
44.	George Hastie	8	0	27/10/38	5/11/38
45.	Robert Chambers	2	-	9/11/38	30/11/38
46.	June Tulloch	7½	4	14/11/38	3/12/38
47.	Ruth Burns	3	1	15/11/38	3/12/38
48.	William Lamb	3	0	18/11/38	20/12/38

No.	Patient.	Age.	Type of H.S.	Admitted.	Discharged
49.	Morag Gowan	25	6	23/11/38	10/12/38
50.	Janet Hanley	25	0	29/11/38	30/12/38
51.	Ronald Nisbet	1	4	2/12/38	24/12/38
52.	Annie Lawrie	1	0	13/12/38	17/12/38
53.	Joseph Murphy	7	4	29/12/38	18/1/39
54.	John Cameron	6	1	11/1/39	7/2/39
55.	John Ward	2½	0	12/1/39	4/2/39
56.	Joseph Pratt	6	18	3/2/39	11/2/39
57.	Margaret Love	3	-	7/2/39	14/2/39
58.	John Archibald	10	9	20/2/39	11/3/39
59.	James McDonough	10	0	21/2/39	25/2/39
60.	Helen Cooper	1½	4	9/3/39	21/3/39

Twenty of the tonsillitis cases gave negative H.S. swabs. The forty positive cases gave a large number of types, namely:-

Type	1	-	12
"	2	-	3
"	3	-	2
"	4	-	9
"	5	-	1
"	6	-	2
"	9	-	1
"	11	-	1
"	18	-	2
"	28	-	1
Unknown types		-	6
Total			40

It will be observed that types 1 and 4 predominated and were in the same relationship to each other as was the case in Scarlet Fever, namely that type 1 predominated in the early part of 1938 and type 4 during the latter end.

Only two complications occurred and these were both due to type 4. Since it is known that at least 40 of these cases were due to haemolytic streptococci the remarkably low complication rate of 5 per cent stands in marked contradistinction to the extremely high complication rate of Scarlet Fever, during this same period. The majority of these 60 cases were under observation and segregated from Scarlet Fever cases. The likelihood of cross infection with other types of streptococcus pyogenes was thus considerably reduced.

I N V E S T I G A T I O N V.

Acute Lobar Pneumonia — Acute Nephritis — Septicaemia
Dermatitis — Erythema — Bronchopneumonia
Erythema Infectiosum — Ac.Rheumatic Fever — Etc.

No.	Patient.	Age.	Type.	Complaint.	Admitted.	Discharged
1.	John Lugton	1	0	Erythema	7/10/38	12/10/37
2.	Ann Hannah	2	0	Erythema	10/10/37	19/10/37
3.	Alice Sterling	2	0	Septic Dermatitis of legs.	11/10/37	19/10/37
4.	Christine Fox	8	2	Erythema	15/10/37	23/10/37
5.	Nancy McPherson,	14	0	Erythema	29/10/37	13/11/37
6.	James Massie	1	0	Erythema	17/11/37	20/11/37
7.	John Dickson	12	0	Erythema	3/12/37	11/12/37

No.	Patient.	Age.	Type.	Complaint.		Admitted & Discharged
8.	Agnes Skinner	1	0	Erythema		2/1/38 8/1/38
9.	Marg. Lawson	2	0	Acute Lobar Pneumonia		5/1/38 18/1/38
10.	Helen Morris	14	(Blood) 5 (Throat) 5 (Urine) 5	Septicaemia & Acute Nephritis.	DIED	19/1/38 20/1/38
11.	Peter Hay	22	0	Erythema		4/2/38 15/2/38
12.	Nurse Cath. Ballantyne	18	18	Ac.Rheumatism		8/2/38 17/3/38
13.	Martin Loy (Vide case 317 page 64.)	2	(Throat) - (Urine) -,4, 11	Scarlet Fever, Nephritis and Bronchopneumonia.	DIED	19/2/38 28/3/38
14.	Eliz. Ramage	1	0	Erythema		23/2/38 26/2/38
15.	Nurse Annie Young	17	(Throat) 0 (Urine) 0	Acute Nephritis		9/3/38 24/3/38
16.	Henry Muir	21	0	Erythema		15/3/38 29/3/38
17.	Mary Gray	8	0	" infectiosum		29/3/38 6/4/38
18.	Andrew Milne	7½	1	Erythema & Scarlet Fever.		31/3/38 14/6/38
19.	Constance Reynolds	6	0	"		11/4/38 19/4/38
20.	Helen McHardy	7	13	Pneumonia		26/4/38 2/5/38
21.	Wm. Hughes	5	28	Erythema infect.		31/5/38 7/6/38
22.	Peter Donelly	1	3	Scarlet Fever, Pneumonia and Empyema		1/7/38 23/8/38
23.	Doreen Forrest	2	0	Acute Pharyngitis		5/8/38 23/8/38
24.	Chas.McDonald	2	0	Erythema		24/8/38 13/9/38

No.	Patient.	Age.	Type.	Complaint.	Admitted & Discharged
25.	Donald Ross	7	(Throat) 2 (Urine) 0	Acute Nephritis	15/9/38 5/11/38
26.	Janet Murray	6	0	Acute Lobar Pneumonia	16/9/38 4/10/38
27.	Eliz. Georgeson,	4	0	Erythema	21/10/38 23/11/38
28.	Alex.Robertson	36	1	Peritonsillar Abscess	23/10/38 3/11/38
29.	Jean Shillinglaw	17	0	Bronchitis	23/9/38 8/10/38
30.	Jas. Hamilton	½	0	Erythema	24/10/38 19/11/38
31.	Walter Mein	4½	0	Tonsillitis & Dermatitis	9/10/38 29/10/38
32.	Myra Anderson	7	-	Erythema Infect.	8/10/38 22/10/38
33.	Eliz. Paterson	7	0	Urticaria & Impetigo	18/10/38 15/11/38
34.	Eliz. McLean	3½	0	Pneumonia	6/12/38 24/12/38
35.	John Dickson	21	1	Erythema	12/12/38 20/12/38
36.	Zena Davidson	41	0	"	16/12/38 31/12/38
37.	Emma Wilson	2½	0	Septic Rash	2/1/39 14/1/39
38.	Gerald White	6	0	Coryza	25/1/39 31/1/39
39.	James Cassie	36	0	Erythema	25/1/39 7/2/39
40.	Wm. Rhind	14	0	"	30/1/39 7/2/39
41.	John Henderson	7 wks.	0	"	30/1/39 7/2/39
42.	Alex. Ferrier	5	0	Urticaria	21/2/39 28/2/39

The above were sent into the City Fever Hospital as cases of Scarlet Fever. All these observation cases

were swabbed with a view to ascertaining what part the haemolytic streptococcus played in the production of such conditions.

Of the 42 cases examined 28 failed to show any haemolytic streptococci.

The thirteen positive cases were as follows:-

4 cases of erythema out of a total of 19.
2 cases of erythema infectiosum out of a total of 3.
1 case of peritonsillar abscess out of 1.
1 case acute nephritis out of a total of 2 cases.
1 case of septicaemia out of a total of 1.
3 cases of pneumonia out of a total of 5.
1 case of acute rheumatism out of a total of 1.

The types met with were:-

Erythema ..... 2; 1; 1; 4. (type 1 present in 2 cases)
" infectiosum 28; -.
Peritonsillar abscess - 1.
Acute Nephritis .... 2.
Septicaemia ..... 5.
Pneumonia ..... 4,-,11; 13; 3.
Acute Rheumatism ... 18.

With the exception of types 5 and 13, all the others were the same as those found in Scarlet Fever.

The only relationship to Scarlet Fever, which is apparent, is the presence of type 28 in case of erythema infectiosum, during May; and an erythema case in February 1939, due to type 4.

I N V E S T I G A T I O N VI.

During November 1938 Dr Gardner swabbed the members of the third year medical class. There was at the time an outbreak of colds and coughs.

From this investigation she obtained a number of positive H.S. swabs, which she typed according to the Lancefield grouping.

I obtained from her eight cultures which she placed in Group A. These were typed as follows:-

Clinical symptoms in students.

Culture	1.	- Type	1	(No symptoms.)
"	2.	- "	-	(" ")
"	3.	- "	-	(Slight cold.)
"	4.	- "	4	(Fauces injected.)
"	5.	- "	-	(No symptoms.)
"	6.	- "	3	(Feeling feverish.)
"	7.	- "	25	(No symptoms.)
"	8.	- "	4	(Recovering from a severe cold.)

During November the epidemiological strains of haemolytic streptococci were 1 and 4. It is interesting to note that three of the five students referred to above had types 1 and 4 in their throats which were the epidemiological strains of Scarlet Fever at the time. Four students showed symptoms the severest of which was due to type 4.

I N V E S T I G A T I O N VII.

In September of 1938 a number of cases of tonsillitis and colds occurred among mine workers at Uphall.

I was acting "locum tenens" for Dr Thomson for a few days and took the opportunity to swab a number of these cases:

	Patient.	Address.	Complaint.	Swab.	Type.
1	Alex. Forbes	Hawthorn Pl. Uphall,	Tonsillitis	Neg.	
2	Ken. Sutherland	Lindens Pl. "	Ac. Pharyngitis	Pos.	-
3.	Alf. McKay	School Pl. "	Coryza	Neg.	
4	Jas. Rodgers	Greensykes Rd. Broxburn	Pharyngitis	Pos.	1
5	Pat. Roach	Strathb. Pl., Uphall	Bronchitis	Pos.	3
6	Mich. McGuigam,	School Pl. "	Ac. Laryngitis	Pos.	3
7	Jas. Carroll,	Kirkhill T. Broxburn	Coryza	Neg.	
8	Jas. Readdie	Middleton Pl. "	"	Neg.	
9.	Alex. McGuire	Eastburn, Broxburn	Tonsillitis	Pos.	3
10.	Isaac Turnbull	Midhope Pl. Uphall	Coryza	Neg.	
11.	John McAuley	Greendy. R. Broxburn	Influenzal cold	Pos.	1
12.	Alex. Shade	Beechw. Cotts., Pumpherston Rd.	Quinsy	Pos.	-
13	Chas. Atkinson	Uphall Station	Coryza	Neg.	
14	Alf. Bell	Main St., Broxburn	"	Neg.	
15.	Jas. Abbott	Cardross Cst. "	"	Pos.	26
16	And. Coleman,	West St., "	Pharyngitis	Neg.	
17	Geo. Collins,	Greendykes R. "	Coryza	Neg.	

	Patient.	Address.	Complaint.	Swab.	Type
18	Wm.Wylie	Latham P.,Pumpherston	Tracheitis	Pos.	3
19	David Dalrymple	Steel Cot. Winchburgh	Tonsillitis	Neg.	
20	Sam.McLelland	West Houston,Uphall,	Coryza	Neg.	
21	John Roach	School Pl. "	Ac.Bronchitis,	Pos.	3
22	Mr Nicholls	Niddrie R. Winchburgh	Influenzal cold	Neg.	
23	Peter Stenhouse	East Main St.Uphall,	Coryza	Neg.	
24	Rob.Millar	Burnbank Ter. "	Coryza	Neg.	
25	Arch.Erskine	Mid St.Broxburn	Rheumatic Fever	Pos.	17
26	Henry Bell	Millgate, Winchburgh	Influenzal cold	Neg.	
27	Thos.Brinckly,	Church St. Broxburn,	Tonsillitis	Neg.	
28	Jas. Lynch	Cardron Crst. "	Tonsillitis	Neg.	
29	Jas.Armstrong,	Pumpherston Rd.	Purulent Rhinitis	Pos.	
30	Philip O'Hanlon	Greensykes Rd., Broxburn,	Pharyngitis	Neg.	
31	Wm.Meechan	" " "	Adenitis	Neg.	
32	Will.Dalrymple	Steel Cot., Winchburgh	Ac.Bronchitis	Pos.	26

Nineteen of the cases were not haemolytic streptococcal infections. More than half of these were coryza.

Of the thirteen streptococcal cases in this epidemic of respiratory complaints, three could not be typed. The ten remaining cases were as follows:-

Type 1 .... 2 cases
" 3 .... 5 cases
" 17 .... 1 case
" 26 .... 2 cases

With the exception of type 17 which was present in a case of acute rheumatic fever, type 3 produced the severest symptoms. The three cases with types 1 and 26 were mild.

Since half the typable strains were of type 3 it appears that it was the major epidemiological strain in that country district during September 1938.

The observation is interesting for it points to the fact that at a place only nine miles from Edinburgh, an epidemic with another strain may occur. During this month not a single one of the 89 cases of Scarlet Fever examined was found to be due to type 3.

(b) HAEMOLYTIC STREPTOCOCCI IN HEALTHY THROATS.

The object of the next series of investigations was to determine whether haemolytic streptococci were present in normal throats and, if so, what the types were, and in what way they were related, if at all, to the types found in Scarlet Fever.

At the outset it was realised that such an investigation, in order to be of much value, had to be fairly extensive if not intensive.

I N V E S T I G A T I O N I.

	Scarlet Fever.	Measles.	Puerperal & Erysipelas.	Diphtheria.
Nurse	1. Type 1	6. Negative	11. Negative	16. Type 1
"	2. " 4	7. Negative	12. Type 7	17. Negative
"	3. Negative	8. Type 1	13. " 1	18. Type -
"	4. Type 7	9. Negative	14. Negative	19. Negative
"	5 " -	10. Negative	15. Negative	20. Type 13
Positives	4	1	2	3

The investigation was again carried out in May 1938 with this result:-

	Scarlet Fever.	Measles.	Puerperal & Erysipelas.	Diphtheria
Nurse	1. Negative	6. Negative	11. Type 7	16. Negative
"	2. Type 28	7. Type 1	12. Negative	17. Negative
"	3. " 1	8. Negative	13. Type -	18. Negative
"	4. Negative	9. Negative	14. Negative	19. Negative
"	5. Type -	10. Negative	15. Negative	20. Type 28

Of the forty nurses swabbed during the two investigations the following numbers showed the presence of various types of haemolytic streptococci in their throats:

Scarlet Fever	7
Measles	2
Puerperal and Erysipelas ..	4
Diphtheria	4

i.e. 17 out of 40 nurses carried H.S.

It is interesting to note the relatively high carrier rate during December-January as compared with May.

These tables point to the following facts:-

(1) Among those nurses most exposed to streptococcal infection the carrier rate is highest. (7 of the 17 carriers were in Scarlet Fever wards.)

Conversely the least number of carriers were found in the measles ward.

(2) It appears that cross infection among nurses occurs.

Thus, in the first table, we find one of the scarlet fever nurses carrying type 7 - a strain common in the erysipelas wards. In the table for May one of the diphtheria nurses was a carrier of type 28, which at the time the swabs were taken was producing an epidemic of complications in the Scarlet Fever wards.

(3) In a fever hospital the nurses appear to become infected predominantly by the epidemiological strains. Only one type, namely 13, was not associated with patients entering the wards with streptococcal infections, at the times these investigations were being carried out.

I N V E S T I G A T I O N II.

Examination of Nurses in a General Hospital.

During January and February 1939 there occurred a number of sore throats among nurses and patients of the Western General Hospital.

Dr Gardner was asked to investigate the matter.

From January 19th to February 14th 80 nurses were swabbed. The process was repeated a number of times if the swabs proved negative. 150 swabs were received in all.

Of the 80 persons swabbed 33, at some stage or other, proved positive. 29 of these were placed by Dr Gardner in the Lancefield group A. I was fortunate in obtaining 19 of these from her and according to Griffith's typing classified them as follows:-

	Type.		Type		Type.
M. 39476 -	4	M. 39060 -	7	M. 39322 -	28
M. 39142 -	7	M. 39207 -	-	M. 39203 -	20

	Type.		Type		Type.
M. 39370 -	4	M. 30411 -	-	M. 38693 -	-
M. 38962 -	17	M. 39843 -	27	M. 39318 -	20
M. 38967 -	20	M. 39142 -	7	M. 39709 -	28
M. 38961 -	20	M. 39221 -	-	M. 39059 -	-

M. 769 - Type 12.

Two nurses were found having type 4
Four " " " " " 7
One nurse was " " " 12
" " " " " " 17
Four nurses were " " " 20
One nurse was " " " 27
One " " " " " 28
Five nurses were " " untypable strains.

Eight of the cases were found to belong to types 7 and 20. This was pointed out to Dr Gardner, for neither of these types are included in the Lancefield Group A. On retyping them according to Griffith's slide agglutination method the above results were confirmed. Sera 7, 16, 20, 21 were tried out on the homologous stock type-specific strains and found to be in order. Dr Gardner assumed that she required new serum, or else that she had got the strains mixed. She is investigating the matter further.

From this investigation it became evident that in the Western General Hospital there existed among the nurses a number of strains of haemolytic streptococci not commonly found among nurses of the City

Fever Hospital. Furthermore only two types, 4 and 28, played a part in the epidemiology of Scarlet Fever.

During the time this investigation was being carried out, type 4 was definitely the preponderating type in Scarlet Fever. Whether it is the isolation of the nurses in the hospital that accounted for the low incidence of the Scarlet Fever strains, or whether immunological factors were involved is a matter for further enquiry.

I N V E S T I G A T I O N III.

Examination of Doctors in the City Fever Hospital.

In December 1937 and April 1938 a number of resident doctors of the City Fever Hospital were swabbed with the following results:-

Swabs:	1st.	2nd.	3rd.	4th.	Types.
Dr D.	Pos.	Pos.	Pos.		1, -, 1
Dr J.	Neg.	Neg.	Neg.		
Dr K.	Pos.	Neg.	Neg.	Pos.	27, 27
Dr McD.	Neg.	Neg.	Neg.	Pos.	-
Dr S.			Pos.	Pos.	1, -
Dr W.	Pos.	Neg.			4

This indicated that the doctors, like the nurses, became carriers of the haemolytic streptococcus, and that the types involved were for the most part the Epidemiological strains.

I N V E S T I G A T I O N IV.

An Investigation upon a Person greatly exposed to Streptococcal Infection from Scarlet Fever Cases.

For this investigation I chose myself.

During the swabbing of Scarlet Fever cases many of the patients coughed directly into my face. Since swabbing was carried out almost daily on a large number of cases, I was undoubtedly heavily infected with haemolytic streptococci.

For the purpose of investigating what occurred under such conditions the following routine was adopted:

Every day on my arrival at the City Hospital a swab was taken. This was repeated after my having been in contact with the Scarlet Fever cases in the wards. This continued for more than a month with the following results:-

	Before entering wards.		After leaving wards.	
1938	Throat swab.	Nasal swab.	Throat swab.	Nasal swab.
Jan.1	Negative	Negative	Pos.(8)	Pos. (8)
2.	Pos. (8)	"	Pos.(8)	Pos. (1)
3.	Negative	Pos. (8)	Pos.(1)	Pos. (3)
4.	"	Negative	Pos.(-)	Pos. (3)
5.	"	"	Negative	Pos. (8)
7.	"	"	"	Pos. (4)
8.	Pos. (4)	Pos. (4)	Pos. (4)	Pos. (2)

1938.	Throat swab.	Nasal swab.	Throat swab.	Nasal swab
Jan. 9.	Pos. (4)	Pos. (4)	Pos. (4)	Pos. (4)
10.	Negative	Negative	Negative	Pos. (4)
11.	"	"	"	Pos. (2)
12.	Pos. (2)	"	Pos. (2)	Negative
14.	Negative	"	Negative	Pos. (1)
15.	Pos. (1)	"	Pos. (1)	Pos. (4)
16.	Negative	"	Negative	Pos. (8)
17.	"	Pos. (8)	"	Pos. (8)
18.	"	Negative	"	Negative
19.	Pos. (8)	"	Pos. (8)	Pos. (1)
21.	Negative	"	Pos. (1)	Pos. (1)
22.	"	"	Negative	Negative
23.	"	"	"	Pos. (8)
24.	Pos. (8)	"	Pos. (8)	Pos. (4)
25.	Negative	"	Negative	Negative
26.	"	"	"	Pos. (-)
28.	"	"	"	Pos. (2)
29.	Pos. (2)	"	Pos. (2)	Pos. (1)
30.	Negative	"	Pos. (1)	Pos. (1)
31.	"	"	Negative	Negative
Feb. 1.	"	"	"	Pos. (-)
2.	Pos. (-)	"	Pos. (1)	Pos. (1)
3.	Pos. (-)	"	Pos. (-)	Pos. (-)
4.	Pos. (-)	"	Pos. (-)	Pos. (4)
5.	Negative	"	Negative	Negative
6.	"	"	Negative	Pos. (1)
7.	Pos. (1)	"	Pos. (1)	Pos. (-)
8.	Negative	"	Negative	Pos. (8)
9.	Pos. (8)	"	Pos. (1)	Negative.

The figures bracketed refer to the types isolated.

It was found that during the period this investigation continued the organisms were on thirteen occasions carried over to the next day in the throat or nose.

On the two occasions January 8th - 9th and February 2nd - 4th, the organisms persisted in the throat for two and three days respectively. No untoward symptoms were experienced.

On 18 occasions, after leaving the wards, the organisms were found in the throat. This contrasts strongly with the 29 occasions on which the organisms were present in the nose after swabbing the cases.

The nasal swab before visiting the wards was positive on only four occasions.

The deductions to be drawn from this investigation are that any one who is heavily infected with haemolytic streptococci from Scarlet Fever cases harbours the organisms for a varying period of some hours to three days in the naso-pharynx. In the majority of cases this infection does not last 24 hours.

Immediately after contact with Scarlet Fever cases the nose is much more heavily infected than the throat. (It is probable that this state would be reversed if the investigator were a mouth breather.)

Since different types were isolated from the throat and nose after contact with patients, on six occasions, it is likely that the same differences

would be found if two or more colonies were picked off each plate grown from either throat or nasal swabs.

As a high degree of immunity must arise from such frequent contact with haemolytic streptococci, this would probably account for the short duration of the presence of the organisms in the upper respiratory passages.

During the early part of my research (viz. September 1937), various symptoms of malaise, mild sore throat, low grade pyrexia, etc., were experienced, and it is to be regretted that this investigation was not then commenced. A comparison of tables might have proved interesting.

(With regard to immunity from contact, it may prove interesting to record that during September 1937, my finger became infected with type 11. After about eight hours' pain was experienced at the site of infection, I was given intramuscular and oral doses of prontosil. For a period of twenty-four hours there was a fever of 101°F.-100.2°F., and slight pain in the axilla. After four days all symptoms ceased.

In August 1938, whilst preparing vaccines a tube containing a heavy deposit of type 4 broke in my hand and some of it entered a cut which had been caused.

I was assured of an immunity to this organism and did no more than wash and dress the cut. Although symptoms were expected nothing occurred, ~~which indicated that~~ although I had become infected with a fairly virulent strain of haemolytic streptococcus.)

I N V E S T I G A T I O N V.

HAEMOLYTIC STREPTOCOCCI IN NORMAL THROATS - Medical Students.

During the early autumn months of 1938 Dr Gardner swabbed the members of the third year medical class.

I was handed ten strains of haemolytic streptococci. These were typed as follows:-

Strain number	1	.....	type	20
" "	2	.....	"	17
" "	3	.....	"	1
" "	4	.....	"	-
" "	5	.....	"	2
" "	6	.....	"	-
" "	7	.....	"	2
" "	8	.....	"	1
" "	9	.....	"	20
" "	10	.....	"	-

None of the above types was associated with clinical manifestations.

I N V E S T I G A T I O N VI.

THE INVESTIGATION OF CARRIERS IN THE FAMILIES OF SCARLET FEVER CASES.

Sixteen families, who had children in the Scarlet Fever wards of the City Hospital, were visited and all members swabbed. This was done with a view to determining whether there were carriers of haemolytic streptococci in such families, and if so, what relationship the types found bore to the patients in the hospital.

The families investigated were as follows:-

(a) LEES family, 6 Cannon St., Leith. (Visited 21/10/37.

Excluding the patient - Edward, age 6 years, there were five people living in two apartments. These were swabbed and typed:

Name.	Occupation.	Type.	Swab.
Thomas (father)	Labourer		Negative
Mrs Lees	Housewife		"
Robert (10 Years)	Scholar at Couper St.		"
Thomas (14 ")	Page boy at Capitol.	25	Positive.
William (3 ")	At home		Negative.

The patient was admitted to hospital 20/10/37 with type 1. He was also a pupil of Couper Street School.

(b) BRYDON family, 9 Portland Place. (Visited 3/11/37).

Excluding the patient - Marion, age 8 years,

there were seven inmates in the two apartments of their flat. They were swabbed and typed:

Name.	Occupation.	Type.	Swab.
Mr Brydon (father)	Labourer	25	Positive
Mrs "	Housewife		Negative
Peggy Muir (18 years) (Lodger)	- (Not at home)		
David (age 7 years)	Scholar at Couper St.	1	Positive
George (" 6 ")	" " " "		Negative
Isabella (3 ")	At home.		"
Sadie (6½ months)	" "		"

The patient was admitted to hospital on November 2nd 1937 with type 1. He was also a member of the Couper Street School which yielded seven cases of Scarlet Fever during October. Five out of the six cases examined were due to type 1.

(c) AIKMAN family, 5 Moat Drive. (Visited 18/11/37)

Excluding the patient - John, age 5 years, there were four inmates living in three apartments:

Name.	Occupation.	Type.	Swab.
David (father)	Labourer		Negative
Mrs Aikman	Housewife	2	Positive
Amelia (7 years)	Scholar at Craiglockhart School	2	Positive
Baby (9 months)	At home		Negative.

The patient was admitted to hospital on November 17th 1937, with type 2. He was a scholar of Craiglockhart School.

This family proved particularly interesting. Amelia had been in the Fever Hospital from 1/10/37 to 26/10/37. Twenty-one days after she had left hospital the patient, John, was sent to hospital with the same type with which Amelia had entered originally. Apparently Amelia was still a carrier. This observation was further strengthened by the fact that shortly after Amelia returned to school, three cases of Scarlet Fever occurred, two of which were due to type 2.

It seems creditable that Amelia was the cause of these three cases of Scarlet Fever.

Whether she had infected her mother or whether Mrs Aikman was the original carrier could not be determined.

(d) GREENAN family, 8 Wauchope Road, (Ground floor). Visited 26/11/37)

Excluding the patient - Jemima, age 5 years, there were five inmates in three apartments:

Name.	Occupation.	Type.	Swab.
Mr Greenan (father)	Motor driver (Smart)	17	Positive
Mrs "	Housewife		Negative
James	Scholar, Craigmillar School		"
Jessie	" " "		"
	(Neither had Scarlet Fever)		
Alex. (3 years)	At home		"

The patient had entered hospital on 16/11/37 with an untypable strain. Mr Greenan was complaining of rheumatic pains.

(e) ARTHUR family, 103 Niddrie Main Terrace 2nd floor). Visited 2/12/37.

Excluding the patient - Helen, age 10 years, - there were nine inmates in three apartments:

Name.	Occupation.	Type.	Swab.
Mr Arthur (father)	Basketmaker	-	Positive
Mrs Arthur	Housewife		Negative
James	Scholar, Niddrie School		"
Mary	" " "		"
Jenny	" " "		"
Babies (2 & 3 years resp.)	At home		"
Miss ? (Lodger)	(Out)		
Miss ? (")	Assistant at Waterston's	-	Positive

The patient had entered hospital on 1/12/37 with type 1.

(f) SUTHERLAND family, 12 Wauchope Ave. (Ground (floor) (Visited 20/3/38)

Excluding the patient - Mary, age 5 years, there were 7 inmates in three apartments.

Name.	Occupation.	Type.	Swab.
Mr Sutherland (father)	Idle		Negative
Mrs Cathon (Lodger)			"
Robert " (6 years)	At home		"
Janet Sutherland (11 years)	Scholar, Willowbrae,	2	Positive
John " (9 years)	Scholar, Craig-millar		Negative
Twins " (3 years)	Kindergarten		"

The patient had entered the hospital on 18/3/38

with type 2. ~~Seven~~ TWO days before Mary's clinical symptoms became manifest Janet Sutherland commenced with tonsillitis. She was still suffering from it when the swab was taken.

It is interesting to note that in both diseases type 2 was found. Which patient infected the other is difficult to determine, but it appears that Janet got the organism from Mary, for during the months of February and March six of the patients who entered hospital with type 2 came from Craigmillar School. Furthermore Janet was attending Willow Brae School where no Scarlet Fever occurred during this time.

The other ten families gave negative swabs.

These were:-

		Visited
(g) McTAGGART	- 4 Spey Street.	1/11/37
(h) STARK	- 63 Trafalgar Lane.	24/12/37
(i) HUNTER	- 231 Niddrie Main	27/12/37
(j) WATSON	- 23 Water Street, Leith	30/1/38
(k) CLARK	- 44 Bristo Street	25/2/38
(l) HARPER	- 8 Hay Road	14/3/38
(m) MARSHALL	- 153 Granton Road	27/3/38
(n) SMITH	- Freer Street	28/3/38
(o) DUFFY	- Wardlaw Place	31/3/38
(p) BURNS	- 5 Parkside Street	2/5/38

In three of the six families visited, a definite relationship between them and the Scarlet Fever cases from the respective families could be found. The other three cases showed no such relationship.

SECTION 2.

CONTAMINATION OF FOMITES WITH HAEMOLYTIC STREPTOCOCCI.

This investigation was carried out with a view to finding out whether haemolytic streptococci were present on the fomites in Scarlet Fever wards.

I N V E S T I G A T I O N I.

Haemolytic Streptococci on Clothes of Scarlet Fever Patients.

In five cases handkerchiefs were obtained from patients on admission to hospital. Each handkerchief was cut into eight portions. One portion of each handkerchief was well shaken up in a quantity of sterile saline. It was then removed and the fluid centrifuged at 2,000 revolutions per minute for 15 minutes. All the fluid was pipetted off with the exception of the last few drops. Loopfuls of this were stroked out on blood-agar plates. The seven remaining portions of each handkerchief were introduced into a sterilised wide-mouthed bottle, and sealed after flaming the end. At weekly intervals a single portion of the handkerchief was removed from each bottle, with long forceps, and plated out by the above method.

The results were as follows:-

Handkerchiefs.

	No.1	No.2	No.3	No.4	No.5
1st week	Type 1	Type 1	Type 2	Type -	Type 1.
2nd "	" 1	" 1	" 2	" -	" 1.
3rd "	" 1	" 1	" 2	" -	" 1.
4th "	" 1	" 1	" 2	" 0	" 1.
5th "	" 1	" 0	" 2	" 0	" 1.
6th "	" 1	" 0	" 2	" 0	" 1.
7th "	" 0	" 0	" 2	" 0	" 1.
15th "	" 0	" 0	" 0	" 0	" 0.

After three weeks all the handkerchiefs still contained haemolytic streptococci. By the 7th week only two handkerchiefs showed live organisms. The bottles were then put aside for 8 more weeks. By that time all the haemolytic streptococci had disappeared.

It must be pointed out that in the sealed bottles a certain amount of moisture was maintained in the handkerchiefs, which may have affected the duration of the viability of the organisms.

I N V E S T I G A T I O N II.

(a) Haemolytic Streptococci on Toys in Scarlet Fever Wards.

On 26/5/38 a number of toys were selected for this purpose, viz: 3 books, 1 celluloid doll, 2 wooden soldiers.

Sterile swabs, dipped in saline, were carefully rubbed over these toys and plated out.

Five of the six plates showed haemolytic streptococci. Four of these were not typed. The only one typed was that obtained from the celluloid doll.

The doll had been in the possession of Mary Morrison - age 2½ years. It later fell from her cot and was picked up by a convalescent, Dorothy Lemon - age 6, who played with it for some while before it was taken away from her for this investigation.

The type found in Mary Morrison was 25, and the type on the toy was also 25, whereas that in the throat of Dorothy Lemon was 1.

Cross infection here was an obvious danger.

(b) Haemolytic Streptococci on Food.

A half-eaten apple which was being shared by two convalescent youths was replaced by a whole one and the part taken away for investigation.

On swabbing the surface and the eaten end, and plating out, numerous streptococci were found. They were not typed.

SECTION 3.

HAEMOLYTIC STREPTOCOCCI IN THE AIR.

I N V E S T I G A T I O N I.

This investigation was carried out with a view to determining the relative incidence of haemolytic streptococci found in the air of Scarlet Fever wards.

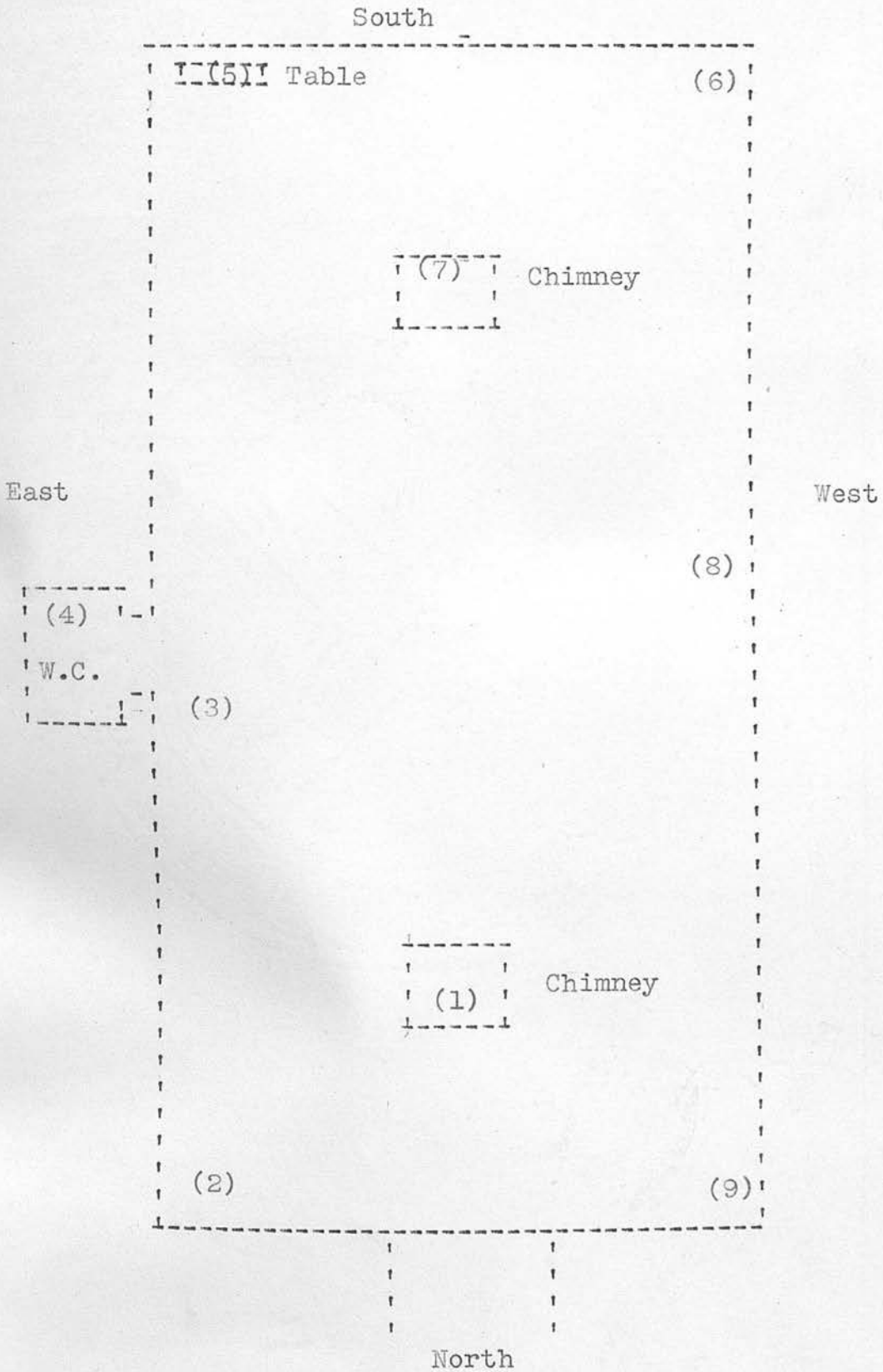
The methods employed had considerable limitations. It is obvious that in order to determine the exact numbers of haemolytic streptococci in the air, special apparatus would be needed whereby the volume of air impinging on the surface of a cultured medium of known area could be calculated.

In this investigation blood-agar plates of 10 cm. diameter were exposed for varying periods of time in predetermined places in the wards.

The figure below indicates the numbers and places given to the various plates:

(See next page)

Plan of Ward



(a) Exposure of Plates from 9 p.m. till 6 a.m.

At 9 p.m. blood-agar plates were exposed in the places indicated on the figure (page 176). At 6 a.m. they were closed by the night nurse.

Date of investigation - 29/3/38

Ward ... 4

Number of cases in ward ... Early (in bed) 13.
... Convalescent 6.

Number of Complications ... Rhinitis 6.
... Otorrhoea 4.

Temperature in ward ..... 12° C.

Relative humidity ..... 83.

Ventilation ..... Five of the hoppers above the windows were partly open (four on the west and one on the east). Four of the windows were open about 4½" (average) on the west side. Two were similarly open on the east side. Such ventilation will be called "poor". Where the majority of windows and hoppers are slightly opened the ventilation will be termed "average". Where the windows are well opened the term "good" will be applied.

Wind velocity ..... 5 (Beaufort Scale).

Prevailing wind .... West.

The bracketed figures indicate the numbers of individual Types isolated.

Results of Investigations:

Plate	Number of H.S. Colonies.	Types.
1.	1	-
2.	0	
3.	1	1
4.	3	1, -, 2
5.	8	1 (3), 4 (2), - (3)
6.	3	25, 1, -.
7.	1	-
8.	0	
9.	0	

(b) Exposure of Plates from 7 a.m. till 9 a.m.

Date ..... 30/3/38.

Ward ..... 4.

No. and Complications of cases in ward .. Same as for 29/3/38.

Air Temperature in ward . 15° C.

Relative Humidity ..... 89.

Ventilation ..... Poor.

Sunlight ..... None.

Wind velocity ..... 6 (Beaufort Scale).

Prevailing wind ..... W. S. W.

Results:

Plate:	Number of H.S.Colonies.	(Only certain no. typed) Types.
1.	5	1 (2), 25
2.	1	6
3.	4	- (2), 2
4.	6	1 (2)
5.	17	3 (2), 1 (4), -(5)
6.	7	1 (2)
7.	5	1 (1), 4 (1), 25 (1)
8.	2	30 ?, 1
9.	0	

Most plates, both in this investigation and in the previous one were heavily contaminated with moulds, alpha haemolytic organisms and staphylococcal-like growths.

It may here be observed that the H.S. colonies on plates, exposed to the air, are frequently deceptive in that they appear opaque, somewhat like haemolytic staphylococci.

In both the above investigations the proportion of haemolytic streptococci to the other organisms was greatest on plate 6.

(c) Exposure of Plates from 10 a.m. to 7 p.m.

Date ..... 30/3/38.

Ward ..... 4.

Number of Cases and Complications - Same as before.

Temperature .. 12° C. to 16° C.

Relative Humidity ... Morning 89, Evening 85.

Ventilation ..... Poor in the morning; Average in the afternoon.

Sunlight ..... None.

Wind Velocity ..... Morning - 6; afternoon - 5. (Beaufort Scale).

Prevailing Wind ... W. S. W.

Results:

Plate.	Number of H.S.Colonies.	Types.
1.	22	1(5), 2(2), 3(1), 4(3), -(7).
2.	4	Only 18 organisms of the
3.	6	1st plate were typed.
4.	4	The organisms on the
5.	64	other plates were dis-
6.	9	regarded.
7.	6	
8.	8	
9.	1	

(d) Exposure of plates from 1 p.m. to 3 p.m.

Plate.	Number of H.S.Colonies.	Types.
1.	1	6
2.	0	
3.	1	-
4.	0	
5.	11	1(2), 8(1), 15(2), -(6)
6.	2	2, -.
7.	1	1
8.	0	
9.	0	

(e) Exposure of Plates from 5 p.m. to 7 p.m.

Date, Ward, Temperature, Ventilation &c., same as before.

Plate.	No.of H.S.Cols.	Plate.	No. of H.S.Cols.	Plate.	No. of H.S.Colonies
1.	1	2.	0	3.	3
4.	1	5.	5	6.	1
7.	1	8.	0	9.	0

Summary.

From 9 p.m. till 6 a.m. 17 colonies were found. This gives approximately four colonies for every two-hour period of the night. From 10 a.m. till 7 p.m. 124 colonies were found. This gives an average of approximately 28 colonies for every two-hour period of the day.

From 7-9 a.m. the number of H.S. found were .. 47
" 1-3 p.m. " " " " " " .. 16
" 5-7 p.m. " " " " " " .. 12

The period of heaviest contamination was during the early morning. The probable explanation for this 7-9 o'clock increase of organisms in the air is that during that time the floors are swept and also that on awakening the patients tend to cough more than at other times of the day and so cause a greater concentration of organisms in the air.

For all further investigation of haemolytic streptococci in the air of the Fever Hospital wards,

this time was taken for the exposure of the plates. (The nurses, in all cases, removed the covers of the Petri dishes.)

I N V E S T I G A T I O N II.

HAEMOLYTIC STREPTOCOCCI IN A PUERPERAL AND ERYSIPELAS WARD.

Date and time of Investigation - 7/4/38. 7-9 a.m.

Ward ..... 15[a]

Ventilation ... Average.

Prevailing wind.. S.S.W.

Results:

Plate.	Number of H.S.colonies.	Type.
1.	0	
2.	2	7, 1.
3.	1	-.
4.	2	- (2)
5.	12	1 (1), 5(1), 7(2), -(3)
6.	2	4.
7.	9	1 (1), 3 (1), - (4)
8.	0	
9.	1	
	29	

Investigation repeated on 20/4/38.

Prevailing wind ... West.

Plate.	No. of Colonies.	Plate.	No. of Colonies.
1.	1	6.	6
2.	0	7.	4
3.	2	8.	0
4.	0	9.	1
5.	8		

These two investigations proved the presence of haemolytic streptococci in puerperal and erysipelas wards. It is observed that type 7 occurs but not types 13 and 27. The first type was found in erysipelas cases and the last two in puerperal cases. From these inadequate numbers of strains typed, it appears that those types found in the cervices of puerperal women do not enter the air.

I N V E S T I G A T I O N III.

HAEMOLYTIC STREPTOCOCCI IN DIPHTHERIA WARDS.

Date of Investigation and time ... 7/4/38. 7-9 a.m.

Ward ... 17

Ventilation ... average.

Prevailing wind ... S.S.W.

Results:

Plate.	Number of H.S.Colonies.	Type.
1.	0	
2.	0	
3.	1	-
4.	0	
5.	5	1(1),11(2),19(1), -(1)
6.	2	11, -.
7.	1	11.
8.	0	
9.	0	

Investigation repeated on 20/4/38.

Prevailing wind ... W.

Plate.	No.of Cols.	Plate.	No. of Cols.	Plate.	No. of Cols.
1.	0	4.	1	7.	2
2.	0	5.	6	8.	0
3.	0	6.	3	9.	1

These investigations proved the presence of haemolytic streptococci in small numbers in the air of diphtheria wards. The types found were 1, 11, 19. Two of these types were not found in any Scarlet Fever cases, throughout this research.

I N V E S T I G A T I O N IV.

HAEMOLYTIC STREPTOCOCCI IN MEASLES WARDS.

Date and time of investigation .. 7/3/38. 7-9 a.m.

Ward .... 20.

Ventilation ... good.

Prevailing wind .. S.S.W.

Results:

Plate.	No. of H.S.Colonies.	Types.
1.	0	
2.	0	
3.	0	
4.	1	1.
5.	3	1(2), 20
6.	0	
7.	0.	
8.	0	
9.	0	

Investigation repeated on 20/3/38. Ventilation, average
Prevailing wind ... W.

Plate.	No. of Cols.	Plate.	No. of Cols.	Plate.	No. of Cols.
1.	0	4.	0	7.	0
2.	0	5.	2	8.	0
3.	1	6.	2	9.	0

These investigations revealed the fact that, in small numbers, haemolytic strains of streptococci were to be found in measles wards.

I N V E S T I G A T I O N V.

HAEMOLYTIC STREPTOCOCCI IN A SCARLET FEVER WARD WITH A LARGE NUMBER OF COMPLICATIONS.

Date and time of investigation .. 29/3/38. 7-9 a.m.

Ward ... 4. (Vide Investigation 1.)

There were 19 cases in the ward, 10 of which had complications (rhinitis .. 6, otorrhoea .. 4).

After incubation the nine plates, which had been exposed for two hours, showed 47 colonies.

This Investigation was carried out in Ward 6 on 10/7/38. At the time there were only two complications (otorrhoea).

The ventilation was good.

The results of exposing the plates were as follows:

Plate.	No.of Cols.	Plate.	No.of Cols.	Plate.	No.of Cols.
1.	0	4.	0	7.	1
2.	0	5.	4	8.	0
3.	1	6.	1	9.	1

Three weeks later the same investigation was carried out. At the time there were three complications - all rhinitis.

Ventilation .... good.

Results:

Plates.	No. of Cols.	Plates.	No. of Cols.
1.	0	5.	4
2.	1	6.	2
3.	1	7.	2
4.	2	8.	0

These last investigations suggest that rhinitis cases account for a higher incidence of streptococci in the air than cases of otorrhoea.

I N V E S T I G A T I O N VI.

HAEMOLYTIC STREPTOCOCCI IN EAR, NOSE AND THROAT WARDS - ROYAL INFIRMARY OF EDINBURGH.

During the months of October, November and December a number of mild pyrexias occurred among the patients of Dr Hall's wards. Some organismal source was suspected and so the matter of air infection was investigated.

(a) On 24/11/38 all the patients in the female ward (13), male ward (13), female side-ward (2) and male side-ward (1) were swabbed. The results were as follows:

Male Wards.			Female Wards.		
Patient.	Swab.	Type.	Patient.	Swab.	Type.
1.	pos.	4	15.	neg.	
2.	neg.		16.	pos.	3
3.	pos.	4	17.	pos.	14
4.	pos.	-	18.	neg.	
5.	pos.	-	19.	neg.	
6.	neg.		20.	neg.	
7.	pos.	1	21.	pos.	1.
8.	pos.	3	22.	pos.	-.
9.	pos.	28	23.	neg.	
10.	neg.		24.	pos.	4

Patient.	Swab.	Type.	Patient.	Swab.	Type.
11.	neg.		25.	neg.	
12.	pos.	20	26.	neg.	
13.	neg.		27.	pos.	2.
Side Ward.			Side Ward.		
14.	pos.	4.	28.	neg.	
			29.	pos.	1.

Sixteen of the twenty-nine cases gave positive swabs. The following is a summary of the types:-

Type 1 ... 3 cases.
" 2 ... 1 case.
" 3 ... 2 cases.
" 4 ... 4 "
" 14 ... 1 case
" 20 ... 1 "
" 28 ... 1 "
Untypable ... 3 cases.

It will be observed that the common epidemiological strains for Scarlet Fever (1,4) were the predominant types in this investigation.

It is unfortunate that an enquiry into the sources of infection of those patients who entered the wards with haemolytic streptococcal infections could not be undertaken. It might have proved interesting to find if any correlations existed between the cases entering the Ear, Nose and Throat Department and those taken to the City Hospital as Scarlet Fever, Puerperal and Erysipelas cases.

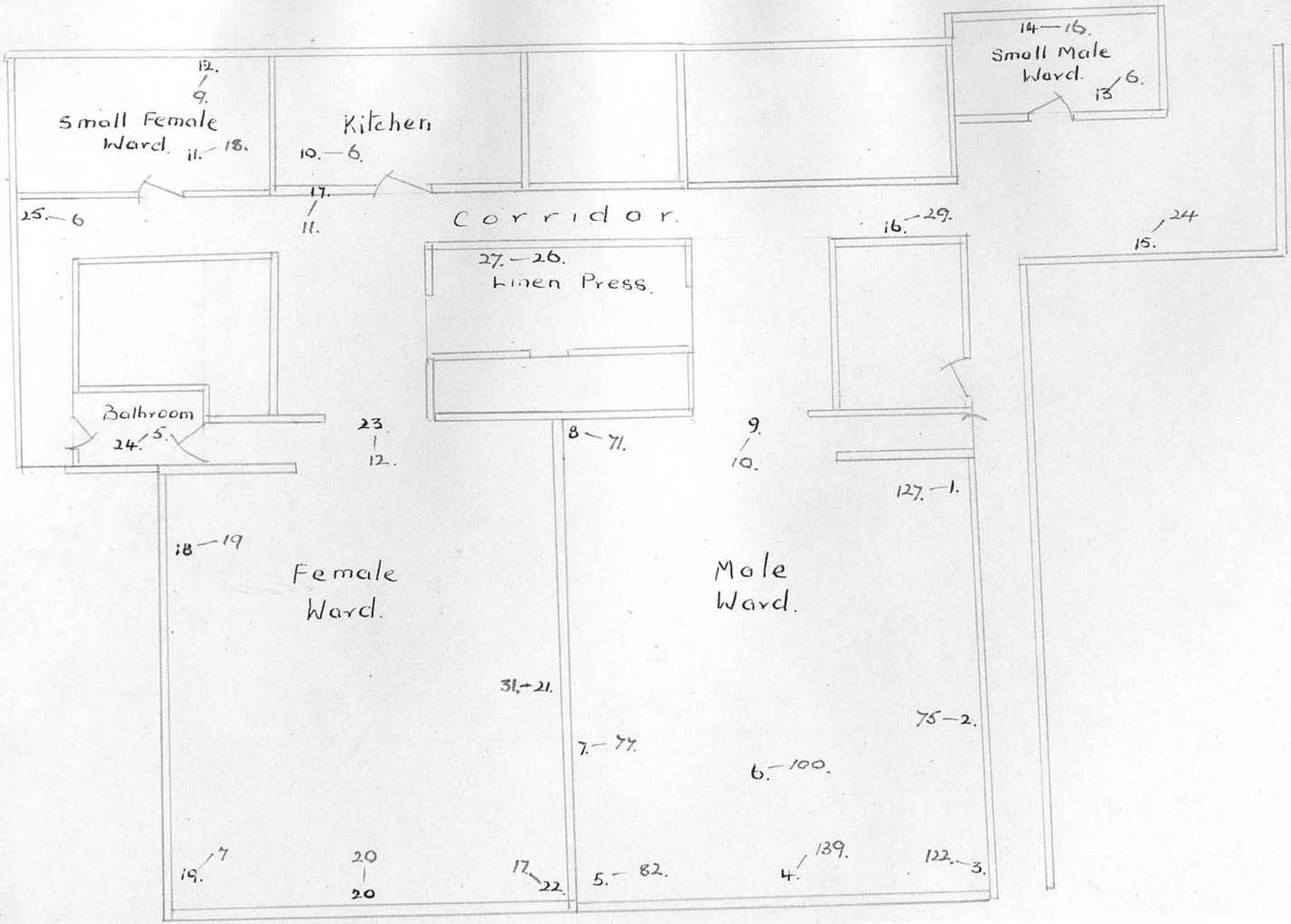
As it was decided that a high percentage of the cases in Dr Hall's wards were infected with haemolytic streptococci, the next problem was to determine the amount of air infection.

On the following sheet is a rough plan of the wards and corridors. The figures in black indicate the positions of the plates, and those in red the number of colonies of haemolytic streptococci found on each.

The plates were exposed from 8 a.m. until 4 p.m.

The ventilation in the wards was totally inadequate, as only a few of the many windows were slightly opened. In the male ward for example, which was the worst, only two windows were open about 5 or 6 inches.

Plan /


12.
9.
Small Female
Ward.
11. — 18.
Kitchen
10. — 6.
14 — 16.
Small Male
Ward.
6.
13
17.
11.
Corridor.
25. — 6
16. — 29.
15.
24
27. — 26.
Linen Press.
Bathroom
24.
5.
23.
12.
8 — 71.
9.
10.
127. — 1.
18 — 19
Female
Ward.
Male
Ward.
31. — 21.
75 — 2.
7. — 77.
6. — 100.
19.
7
20
20
17.
22.
5. — 82.
4.
139.
122. — 3.

The number of colonies in the large male ward was relatively the highest. This was in agreement with the fact that the males gave a higher number of positive swabs. The poorer ventilation is another factor which led to a higher incidence of streptococci in the air.

Three colonies from each plate were typed. The results are here tabulated:

Plate.	No.of H.S. Colonies.	Types.	Contamination with other organisms.
1.	127	4, 1, -.	Fairly heavily infected.
2.	75	2, 17, 1.	" " "
3.	122	1, 1, -.	" "
4.	139	1, 4, 1.	" "
5.	82	2, 20, -.	" " "
6.	100	28, 1, 4.	" " "
7.	77	1, 1, 1.	" "
8.	71	2, 3, 1	" " "
9.	10	4, -, 1	" " "
10.	6	4, 1, 7	" " "
11.	18	1, 1, -.	" "
12.	9	-, 1, 1,	" " "
13.	6	4, 1, 1.	" "
14.	16	1, 2, 1.	" "
15.	24	17, 1, -.	" " "
16.	29	-, -, -.	" " "
17.	11	4, 1, 1.	Mildly "
18.	19	1, 1, 1.	Heavily "
19.	7	3, 27, 1.	" "
20.	20	14, 2, 2.	" "
21.	31	1, 4, -.	" " "
22.	17	1, 19, 14.	" "
23.	12	4, 1, 2.	Mildly "

Plate.	No.of H.S. Colonies.	Types.	Contaminiation with other organisms.
24.	5	1, -, -.	Fairly heavily infected.
25.	6	7, 1,30?	Mildly "
26.	27	1, 4, 5	Heavily "

The strains isolated were:-

Type 1	32.	Type 17	2
" 2	7.	" 19	1.
" 3	2.	" 20	1.
" 4	10.	" 27	1.
" 5	1.	" 28	1.
" 7	2.	" 30 ?	1.
" 14	2.	Untyped	15.

As will be observed from the plan on page 189, it was not only the wards which were infected but also the annexes - bathrooms, linen room, kitchen, lobbies and passages.

This investigation proved a number of facts:

(1) The air of the wards of the Ear, Nose and Throat Department was heavily infected with haemolytic streptococci.

(2) The organisms were carried from the wards to other parts of the buildings.

(3) The types present in the air, which predominated, were mainly the major epidemiological strains responsible for Scarlet Fever at that time.

(b) On January 1st, 1939 blood-agar plates were exposed in the operating theatre adjoining the wards. The time of exposure was three hours (11 a.m. to 2 p.m.) during which operations took place.

The following were the results:-

Sterilising Room.	S.viridans.	H.S.	Pneumococci.	Staphylococci.	Meningococci.	Others
Above sink ..	0	1	1	98	0	Many.
On medicine chest ..	1	1	1	93	2	"
Operating Theatre.						
Table on left	0	0	0	70	0	Many.
Under oper.tab.	0	0	0	60	0	Few.
Chair rt. of door	0	0	0	60	1	"
Above wash basin	0	0	2	64	0	"
" X-ray cabinet	0	0	0	20	0	"
In servery	1	0	0	33	0	"
Behind Inst. Table	1	1	2	64	0	Many.

It may be observed that in the operating theatre, unlike in the wards, there was a marked absence of haemolytic streptococci, although staphylococci proved to be particularly numerous.

As most of the pyrexias only occurred some days after the patients had been in the wards, it may reasonably be surmised that they were due to infection there and not in the theatre.

If this is the case it points to the fact that it is the streptococcus and not the staphylococcus which is the cause of the pyrexias, for staphylococcal infection of the patients most likely occurred in the operating theatre, owing to the large numbers of that organism found on the exposed blood-agar plates.

This matter needs closer investigation.

I N V E S T I G A T I O N VII.

HAEMOLYTIC STREPTOCOCCI IN PICTURE HOUSES

(by permission of the Managers).

(a) On September 22nd, 1938, blood-agar plates were exposed in the rush of air in one of the mechanical ventilation shafts, situated above the hall of the Caley Picture House.

The investigation was carried out from 2 till 2.20 p.m. At the time there was no epidemic of coughs, tonsillitis or colds.

When the plates were exposed the "house" was about half filled and the picture had been in progress about half-an-hour.

The plates were held in the air for periods varying from one second to fifteen minutes.

The results were:-

Plate					
1,	exposed for	1 second	- No H.S.	No	contaminating orgs.
2,	"	" 5 "	- "	1	do.
3,	"	" 10 "	- "	1	do.
4,	"	" 20 "	- "	5	do.
5,	"	" 1 min.	- "	15	do.
6,	"	" 2 "	- "	20	do.
7,	"	" 3 "	- "	59	do.
8,	"	" 5 "	- "	123	do.
9,	"	" 10 "	- "	300	do.
10,	"	" 15 "	- "	483	do.

This investigation showed that shortly after the picture house had opened, during a time when there were very few streptococcal infections, none of these organisms was found in the air which was exhausted from the hall.

(b) On November 23rd 1938, the above investigation was repeated in the Caley Picture House.

At the time there was an epidemic of sore throats.

The plates were exposed in the exhaust air for varying periods.

This investigation was commenced about 6 p.m.

Plate					
1	exposed for	1 second	- No H.S.	2	contaminating Orgs.
2	"	" 5 "	- "	14	" "
3	"	" 10 "	- 2 H.S.	34	" "
4	"	" 20 "	- 11 "	78	" "

Plate							
5	exposed for	1	min. -	26	H.S.	213	contaminating Orgs.
6	" "	2	" -	49	"	439	"
7	" "	3	" -	61	"	700	"
8	" "	5	" -	92	"	900	"
9	" "	10	" -	230	"	1900 (approx.)	"
10	" "	15	" -	420	"	Very heavily infected.	

Six of the haemolytic streptococci were subcultured, five of these were typed as follows:-

Type -.	Type 1.
" 4.	" 1

Type 21.

(c) On September 22nd 1938, plates were exposed within the hall of the Caley Picture House.

At the time there was no epidemic of tonsillitis, etc.

Two racks were made upon each of which could be secured, by means of adhesive tape, four blood-agar plates.

In each of the four corners a plate was exposed.

From 2.30 till 5 p.m., the plates were open to the air for varying periods. I was assisted by a technician from the Bacteriology Department (Bertram). We held the plates on our laps and sat in different parts of the hall.

The house was practically full at four o'clock.

This investigation revealed the following results:-

Plate.	Time exposed.	H.S.	Other Organisms.
1	¼ hour	0	None.
2	½ "	0	Few.
3	¾ "	0	"
4	1 "	0	"
5	1½ "	0	"
6	1¾ "	0	"
7	2 "	0	Numerous.
8	2½ "	0	"
9	2½ "	0	Few. (Plate from back left corner)
10	2½ "	0	Numerous.(" front right corner)
11	2½	0	Few.(Plate from back right corner)
12	2½	0	Few. (Plate from front left corner).

(d) The previous investigation was repeated at the New Victoria Picture House, on the same day, from 5.35 - 8.45 p.m., with the following results:-

Plate.	Time exposed.	H.S.	Type.	Other Organisms.
1.	¼ hour	0		Numerous.
2.	½ "	0		Few.
3.	¾ "	1	1	"
4.	1 "	0		Numerous.
5.	1½ "	0		"
6.	1¾ "	0		"
7.	2 "	0		Very "
8.	2½ "	0		" "

Only one streptococcus was found in these two investigations. It was type 1.

The majority of contaminating organisms were Gram negative haemolytic coliform bacilli, S.viridans and moulds.

(e) The above investigation was repeated in the Caley Picture House on November 23rd, 1938. As previously mentioned it was a time of tonsillitis and respiratory infection.

The plates were exposed as before, commencing at 5 p.m. and continuing till 7.35 p.m.

Results.

Plate.	Time exposed.	H.S.	Type.	Other organisms
1.	¼ hour	0		One
2.	½ "	2	1, -.	Few.
3.	¾ "	1	-.	"
4.	1 "	5	1, 18, 5	"
5.	1½ "	7	1, 4, -.	"
6.	1¾ "	6	2, 4, 4.	"
7.	2 "	20	-. 8. 1.	Many.
8.	2½ "	14	-, -, 4.	Numerous.
L. back	2½ "	17	11, 1, -.	"
R. "	2½ "	20	18, 4, -.	"
L. front	2½ "	23	-, -, -.	Very Numerous.
R. front	2½ "	10	1, 4, 4.	" "

From these investigations the facts deduced were:-

(1) During a period when tonsillitis and respiratory complaints were few in number the picture houses had very few haemolytic streptococci in the air, although contaminations with other organisms were very heavy.

(2) Conversely, during an epidemic of sore throats, etc., the incidence of air-borne streptococci was high at a level lower than the head, notwithstanding the fact that induced air-currents moved upwards.

(3) The balanced system of ventilation removed large numbes of haemolytic streptococci and other organisms from the halls of the picture houses, Even short exposures of a minute or less of blood-agar plates in the exhaust air showed numbers of haemolytic streptococci.

(4) Various types of this organism were found in the air of the bioscopes which were investigated. The predominant types were the same as those of Scarlet Fever and other haemolytic streptococcal infections prevailing at the time.

I N V E S T I G A T I O N VIII.

STREPTOCOCCI IN THE AIR OF BUSES AND TRAMS.

At various times plates were exposed in buses and trams:

(1) Bus - Morningside to Blackhall.

(2) Bus - Teviot Place to Stenhouse Terminus.

(3) Bus - Randolph Place to Pilton Terminus.

(4) Tram - G.P.O. to Corstorphine Terminus.

(5) Tram - Nicolson Street to Granton Road Station.

(6) Tram - G.P.O. to Joppa.

In each case both the outward and the return journeys were made and the plates exposed the whole time. Only two plates could be managed at once.

The investigation was carried out in July, 1938, when weather was fine and the ventilation of the vehicles very good. It was also a time when respiratory complaints were uncommon. In December the investigation was repeated, at a time when the ventilation of the vehicles was almost nil and numbers of the passengers were coughing.

The differences in the plates after incubating them was striking:-

JULY.

Bus or Tram.	Plates.	Colonies of H.S.	Other Organisms.
1.	(a)	0	3
	(b)	0	5
2.	(a)	0	1
	(b)	0	4
3.	(a)	0	2
	(b)	0	1
4.	(a)	0	5
	(b)	0	7
5.	(a)	0	16
	(b)	0	17
6.	(a)	0	24
	(b)	0	10

DECEMBER.

Bus or Tram.	Plates.	Colonies of H.S.	Types.	Other Organisms.
1.	(a)	10	1,.1,.-.	Numerous.
	(b)	28	2, 1, -.	"
2.	(a)	15	8, 8, 4.	"
	(b)	5	-, 1, 4	"
3.	(a)	25	10, 1, -.	"
	(b)	8	4, 1, 4.	"
4.	(a)	17	-, -, 1.	"
	(b)	23	1, 1, 16.	"
5.	(a)	13	-, 7, -.	"
	(b)	28	-, 7, 4.	"
6.	(a)	80	15, 1, 1.	"
	(b)	123	1, 1, 1.	"

The gross contamination of the air during the mid-winter, when the trams and buses have all windows closed, and numerous people are coughing, is well illustrated in the result of the second investigation. There is a most marked difference between the two periods - July and December. The vehicles during the latter period appear to be literally organismal traps.

Of the various types found, 1 and 4 were predominant.

I N V E S T I G A T I O N IX.

(a) Scott Memorial. (18/12/38)

Four plates were exposed on the top balcony of the Memorial for six hours. During this period no visitors ascended.

The organisms found were:

4 moulds,

2 staphylococci,

1 haemolytic streptococcus.

The type of the last-named could not be determined.

(b) Woolworth Shop.

Investigation carried out on 24/12/38.

On a Saturday evening I walked through the shop with an exposed plate. So many contaminating organisms were on the plate that it was impossible to tell whether any haemolytic streptococci were present.

The following week a plate was exposed in the shop for 10 minutes only. The result was as follows:

Haemolytic streptococci 2,

Staphylococci 21,

Various other organisms 61.

The two streptococci belonged to type 17 and an untypable strain.

SECTION 4.

S U M M A R Y .

(1) 54 cases of puerperal fever were examined over a period extending from October 1937 to November 1938. 42 cases gave positive swabs, either from the cervix, throat or blood, and in one case a positive swab from the breast.

All the types found, except one, corresponded to those in Scarlet Fever.

A certain relationship between the relative increase and decrease of the two conditions existed.

(2) 40 cases of erysipelas were examined between December 1937 and December 1938. In only three cases were there no haemolytic streptococci found. In 10 cases the type in the lesion and throat was the same. 20 of the 40 throat swabs were negative.

Types 1 and 7 were the predominant strains encountered.

Young patients gave a higher percentage of the common epidemiological strains for Scarlet Fever than the older patients. This indicated that the sources of infection in these younger patients were probably the same for the two conditions.

One patient who appeared to be a carrier of type 7 developed erysipelas twice from this strain.

(3) Otitis media and Mastoiditis.

10 cases of otitis media or mastoiditis were

examined. 4 gave positive swabs and showed the presence of types 1, 4 and 14.

(4) Tonsillitis.

60 cases of tonsillitis were examined in the City Fever Hospital. 40 gave positive H.S. swabs.

The common types met with were 1, 2 and 4.

(5) A miscellaneous group of complaints was examined including - pneumonia, erythema infectiosum, acute nephritis, erythema, septicaemia and acute rheumatic fever.

42 cases were examined, of which thirteen showed the presence of haemolytic streptococci in their throats.

Various types were found. With only two exceptions, namely 5 and 13, all the other types were scarlatinal strains.

(6) Medical Students.

A number of medical students were swabbed. Out of 8 students four gave positive swabs and showed symptoms of infection. Types 1, 3, 4, 25 were found.

(7) Rural Workers.

A number of rural workers, complaining of tonsillitis, etc., were examined at Uphall. 13 out of 32 cases were due to haemolytic streptococci. Type 3 predominated. Other types present were 1, 17 and 26.

(8) Nurses. (Fever Hospital).

40 nurses were swabbed in the City Fever Hospital - 20 during December 1937 - January 1938, and 20 during May 1938.

The scarlet fever nurses showed the highest evidence of positives. During December-January the carrier rate was higher than in May. The common epidemiological strains of both periods were the types which occurred most frequently in the nurses.

(9) Nurses (General Hospital)

The swabs of a number of nurses in the Western General Hospital were examined, and types 4, 7, 12, 17, 20, 27 and 28 were isolated. No relationship of types to scarlet fever types was found.

(10) Doctors. (City Fever Hospital)

Of 6 doctors in the City Hospital, who were swabbed, 5 gave positive swabs on one or more occasions.

The types met with were 1, 4, 27.

(11) Results of frequent contact with Scarlet Fever cases.

From January 1st to February 9th 1938 an investigation was carried out to show the extent of infection after direct contact with Scarlet Fever cases. On thirteen occasions the types found in the nose or throat, after contact, were carried over to the next day, but on only two occasions the organisms persisted in the throat for more than a day. During the 40 days that the investigation lasted, organisms were present in the nose, directly after contact, on 29 occasions. On 18 of these occasions they were found in the throat. The 29 positive nasal swabs, after contact, contrast strongly with the 4 positive swabs obtained from the nose before contact.

(12) Healthy Medical Students.

Early in the autumn of 1938 the healthy throats of a number of medical students were shown to harbour types 1, 2, 17, 20, and unknown strains

(13) Families of Scarlet Fever Patients.

During various periods six of the families of scarlet fever patients were visited and all the members swabbed. In three of these certain members were positive. A relationship between the types found at home and those from the patients in the hospital could be traced.

(14) Clothes, Toys, Food.

Haemolytic streptococci infected clothes, toys and food handled by Scarlet Fever patients.

(15) Air Contamination.

The air of Scarlet Fever wards was shown to contain haemolytic streptococci which were largely the same types as those found in patients in the wards. The number of streptococci in the air depended to some extent upon the number and type of complications present.

(16) Wards.

Puerperal fever and erysipelas, diphtheria, and measles wards were shown to have varying numbers of haemolytic streptococci in the air. The measles ward gave the lowest figures.

The air in the wards of the Ear, Nose and Throat

Department of the Royal Infirmary was shown to have large numbers of haemolytic streptococci.

The types found had a relationship to the Scarlet Fever types.

(17) Air in other places.

The air of picture houses, buses, trams, shops, etc., was investigated and found to be contaminated with haemolytic streptococci. The numbers depended upon the presence of respiratory infections.

P A R T V.

CORRELATION BETWEEN SCARLET FEVER AND OTHER HAEMOLYTIC STREPTOCOCCAL INFECTIONS.

It seems to be fairly clearly established, from the investigation of the complications of Scarlet Fever (page 71.), that the vast majority of the complications are due to haemolytic streptococci. These can hardly be regarded as part of the scarlatinal syndrome. They should be more correctly looked upon as accidental streptococcal infections. The chief factor in the production of these complications appears to be cross-infection with other types. This is borne out by the fact that of 384 complications investigated, 280 were due to types differing from those with which the patients had entered the hospital.

That a direct link exists between Scarlet Fever and these complications, is undoubtedly the case, since it is found that frequently a certain type, which had been introduced into a ward, accounts for a series of complications.

Where the links between Scarlet Feve and other streptococcal infections exist, is not such an easy matter to decide.

Scarlet Fever may arise in one or more of the following ways:-

(1) From direct contact with another case, either

(a) during the incubation period,

or (b) during the stage of clinical manifestations,

or (c) during convalescence, with or without complications and discharges.

(2) From direct contact with healthy carriers or sub-clinical cases.

(3) From other streptococcal infections:

(a) Tonsillitis, pharyngitis, rhinitis, etc.

(b) Rheumatic fever.

(c) Puerperal fever.

(d) Erysipelas.

(e) Otorrhoea, otitis media, etc.

(4) From air contamination with haemolytic streptococci.

(5) From fomites.

Although this problem has not been fully investigated, an attempt has been made to collect as much data, as time permitted, on the various aspects of the subject enumerated above.

As a result of this investigation the general conclusion is that a relationship between the types of haemolytic streptococci in the various clinical manifestations of disease they produce exists. This relationship appears primarily in the major epidemiological types prevailing at any particular time. For example, it has been found in this research that types 1 and 4 were the types which produced most of the streptococcal diseases. The occurrence of other types

was, for the most part, confined to particular streptococcal diseases, sporadic in their occurrence and topographically limited.

P A R T VI.

THE PROBLEM OF AIR-BORNE INFECTION IN FEVER HOSPITAL WARDS.

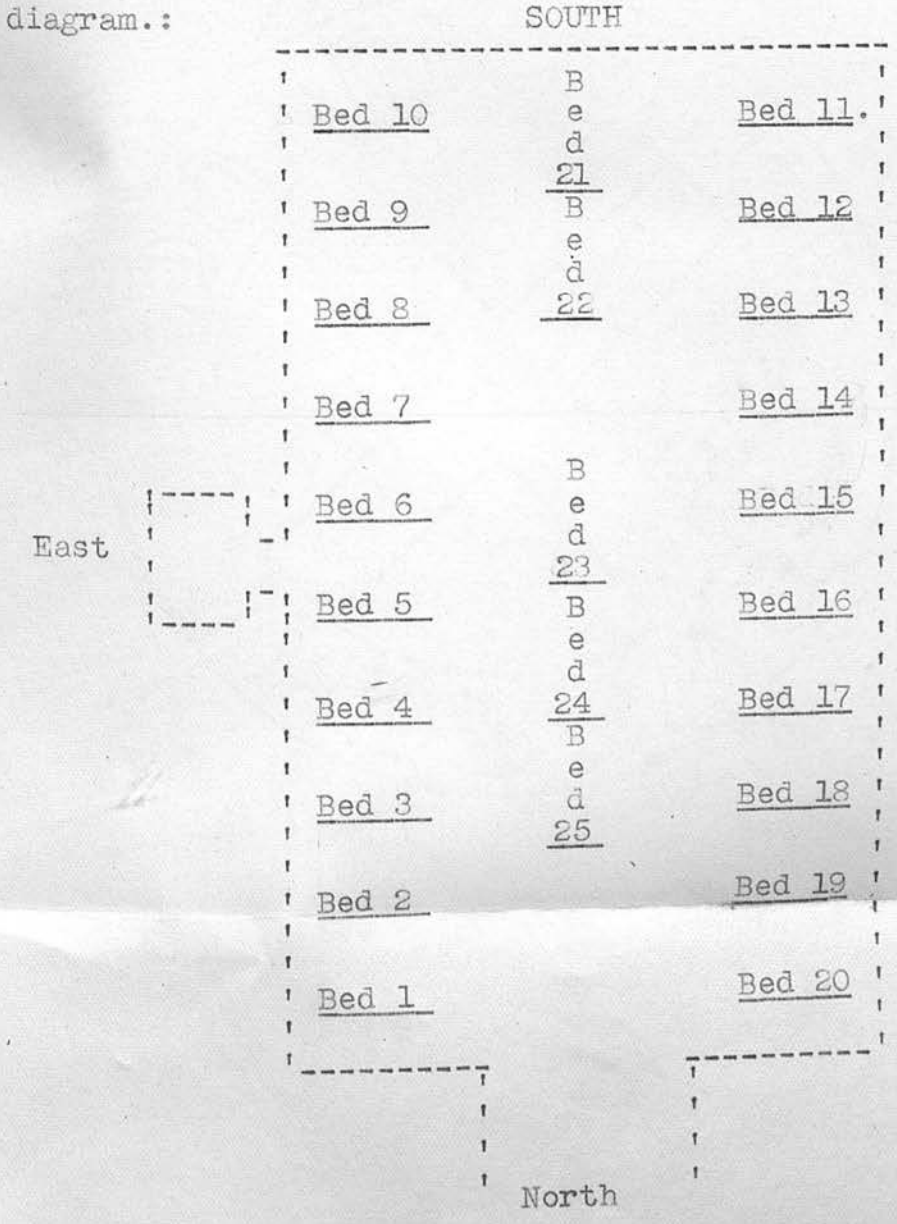
Organisms are undoubtedly carried through the air of fever wards. In order to appreciate the problems of cross-infection and the cause of complications of scarlet fever patients, it was deemed necessary to enquire into this matter.

The observation that in certain parts of the wards a relatively greater number of complications occurred than in other parts, really initiated this investigation.

The following investigation brings out this point:-

I N V E S T I G A T I O N I.

The position of the beds in the wards is indicated in the diagram.:



Results of Investigation:

Date ... 30/6/38.

Ward.	No. of Bed.	Complication.	No. of Patient.
4	5	Otorrhoea.	18
	9	Adenitis.	
	10	Otorrhoea.	
	13	Otitis Media.	
Date ... 30/7/38.			
4	11	Otorrhoea.	19
	12	Rhinitis.	
2	8	Otorrhoea	25
	10	Adenitis	
	3	"	
6	5	Adenitis	16
	12	"	
	15	Arthritis	
	18	Otorrhoea	
	19	Adenitis.	
Date ... 26/9/38			
4	11	Adenitis	26
	12	Otorrhoea and adenitis	
2	1	Vaginitis (B. coli)	25
	2	" (H.S.).	
	9	Adenitis & Pyelitis	
	11	"	

Date ... 26/9/38.

Ward.	No. of Bed.	Complication.	No. of patient.
6	2	Rhinitis	21
	7	Adenitis	
	12	Otorrhoea.	
Date ... 10/10/38.			
4	7	Otorrhoea	21
	10	Adenitis	
	11	"	
2	5	Vaginitis	24
	9	Otorrhoea	
	10	Adenitis.	
6	9	Adenitis	19
	10	"	

It is seen that in the ten observations made 31 cases with complications were encountered. According to the beds occupied by them they may be classified as follows:-

Bed	No. 1	.....	Patients	1.
"	" 2	.....	"	2.
"	" 3	.....	"	1.
"	" 5	.....	"	3
"	" 7	.....	"	2

Bed	No.	8	..... Patients	1.
"	"	9	..... "	4.
"	"	10	..... "	5.
"	"	11	..... "	4.
"	"	12	..... "	4.
"	"	13	..... "	1.
"	"	15	..... "	1.
"	"	18	..... "	1.
"	"	19	..... "	1.

Seventeen of the complications were found in beds Nos. 9, 10, 11, 12. That this is no mere coincidence is shown by the fact that in nearly all the observations the four south-end beds held the highest number of complications.

The earlier observation that the highest concentrations of haemolytic streptococci in the air (vide p. 177 et seq.) occurred at the south end of the wards, appears in some way to be related to the conclusions of this investigation, namely, that the majority of complications occurred at the same end of the wards.

With these facts in mind ward-ventilation was studied.

(The following investigations were carried out with standardised suspensions of B. prodigiosus.

Heavily inoculated agar plates were incubated for 24 hours and the growth then suspended in sterile

normal saline. This was diluted to the standard of Brown's Opacity Tube No.4, and poured into an atomiser.

The strain of B. prodigiosus employed was a particularly good one. After incubation the plates, which were exposed in the wards, they were left at room temperature for 24 hours. This brought out well the red colour of the organism, and prevented any confusion with staphylococci, etc. when the colonies were counted).

I N V E S T I G A T I O N II.

RATE OF SPREAD OF B. PRODIGIOSUS FROM ONE END OF THE WARD TO THE OTHER.

Date of Investigation ... 31/12/39.

Ward ... 4.

Wind ... Direction: S.S.W.
Velocity: Low.

Ventilation ... Average (See p. 177). Large bottom door (South) closed.

There were 18 patients in the ward and the nurses were throughout this investigation causing air-currents by their movements about the ward.

The organisms were sprayed with the atomiser from the extreme south end of the ward, whilst the plates were exposed right at the north end.

The length of the ward is approximately 41 yards. The distance between the point of spraying and the plates would thus be about 40 yards.

An indefinite number of puffs were given with the atomiser.

Results:

Plate	1	exposed for	½	min.	No. of colonies found			0
"	2	"	"	1	"	"	"	1
"	3	"	"	2½	"	"	"	7
"	4	"	"	4	"	"	"	3
"	5	"	"	5	"	"	"	8
"	6	"	"	6	"	"	"	8
"	7	"	"	10	"	"	"	21
"	8	"	"	15	"	"	"	41
"	9	"	"	20	"	"	"	61
"	10	"	"	½	hr.	"	"	81

Control:

Two hours before the investigation was begun three plates were exposed at different points in the ward in order to ascertain whether there were any B. prodigiosus present.

These showed: North plate ... none.
Middle " ... "
South " ... ".

I N V E S T I G A T I O N III.

The previous experiment was repeated on 1/2/39. Wind ... The direction was from S.W. and was of low velocity.

In this investigation the large double door at the bottom end of the ward was opened. This caused a gentle wind to blow from the south end to the north end of the ward.

Control: No B. prodigiosus found.

Results:-

					No. of colonies found
Plate	1	exposed for	5	secs. ...	0
"	2	" "	10	" ...	0
"	3	" "	15	" ...	10
"	4	" "	20	" ...	17
"	5	" "	30	" ...	29
"	6	" "	1	min. ...	57
"	7	" "	2	" ...	82
"	8	" "	3	" ...	91
"	9	" "	5	" ...	93

The rate of spread of B. prodigiosus from one end of the ward to the other was somewhere between 10 and 15 seconds. After two minutes the number of organisms on the plates exposed for longer periods, increased comparatively little.

I N V E S T I G A T I O N IV.

RATE OF SPREAD OF B. PRODIGIOSUS IN A CLOSED UNOCCUPIED WARD.

Ward ... 19. This ward was unoccupied at the time.
Date ... 1/1/39.
Wind ... direction E.N.E. Velocity - Beaufort Scale 5.

Ventilation ... All the windows and doors were closed. There was no demonstrable air movement from end to end or across the ward.

This was tested by observing the smoke of a cigarette. The radiators were, however, on, and the smoke, when gently blown above them, rose more rapidly to the ceiling than in other parts, and then slowly diffused in all directions.

A number of agar plates were exposed at the south end of the ward. At the north end B. prodigiosus were sprayed directly upwards into the air.

Results:

	No. of colonies found
Plate 1 exposed for 1 minute.	0
" 2 " " 2 minutes	0
" 3 " " 3 "	0
" 4 " " 5 "	0
" 5 " " 6 "	0
" 6 " " 7 "	0
" 7 " " 8 "	0
" 8 " " 9 "	0
" 9 " " 10 "	28
" 10 " " 20 "	80
" 11 " " ½ hour	130
" 12 " " 1½ "	113.

In this closed ward, which showed no movement of the air in the same direction as the wind blowing outside, it took 10 minutes for the organisms to spread from one end to the other - a distance of

approximately 40 yards. That the radiators played a definite part in the diffusion of the air cannot be doubted, but this diffusion was a regular one and did not cause a definite flow of air from one end of the ward to the other.

I N V E S T I G A T I O N V.

DETERMINATION OF THE MOST SUITABLE CONCENTRATIONS OF B. PRODIGIOSUS SUSPENSIONS FOR SPRAYING INTO THE AIR IN SUBSEQUENT INVESTIGATIONS.

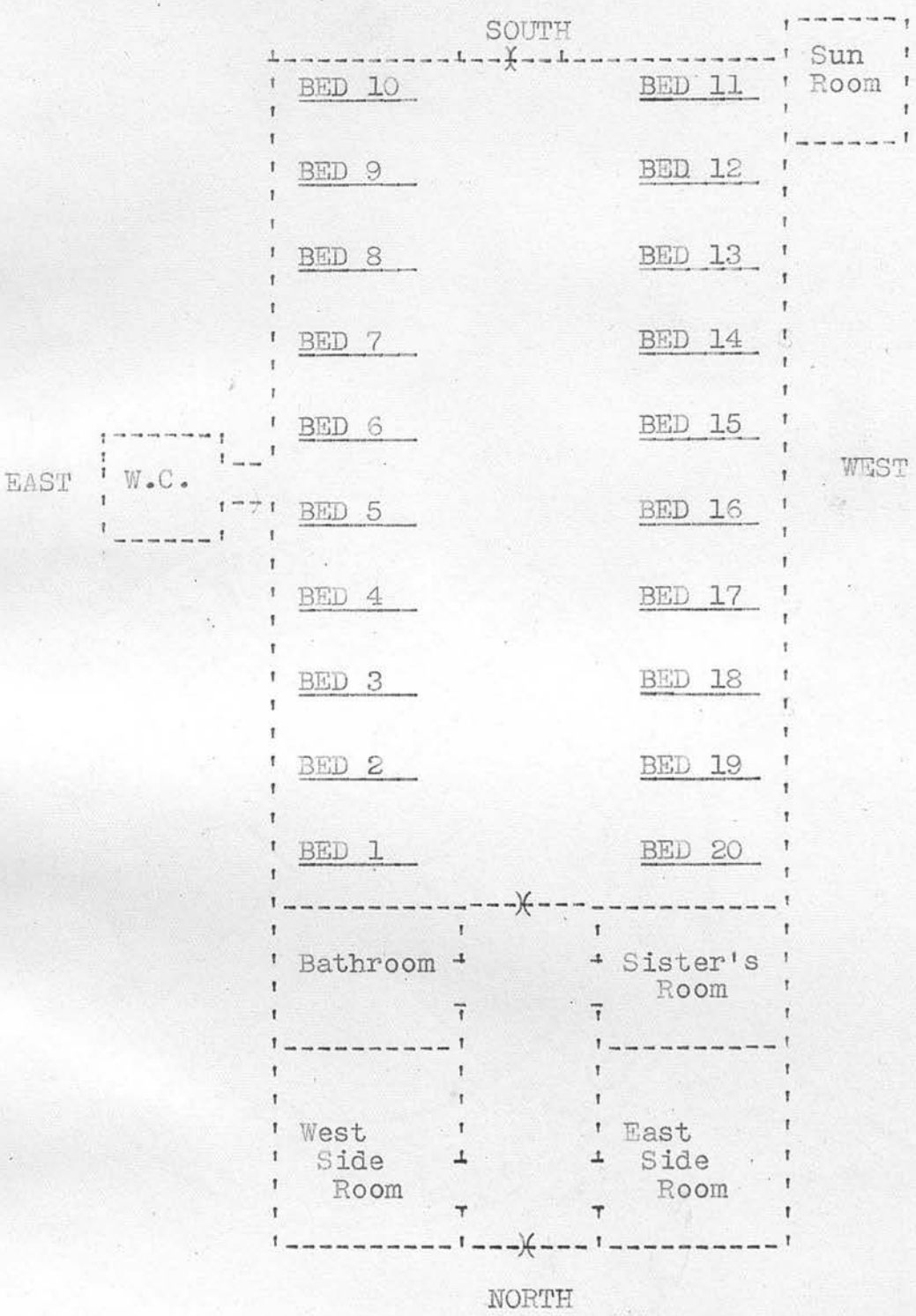
In an average ventilated ward, a suspension of B. prodigiosus, corresponding to Brown's opacity tube No.4, was sprayed into the air. Two puffs with the atomiser were made from the head-end of each of the side-beds in the ward. The direction was that which the patient would adopt when coughing.

Before the spraying was commenced plates were laid out in the ward, on some of the bedside tables of the patients, and other places which are indicated in the following diagram.

The direction of the wind at the time the investigation was being carried out was W.S.W. The velocity was low.

Immediately after spraying the organisms into the air the covers of the plates were removed, commencing with the plate farthest from the point last sprayed. This allowed for the larger drops to settle down.

Plan Showing Lay-Out of Plates



The standardised suspension of B. prodigiosus was taken to represent "full strength". (Brown's Opacity Tube No.4). The subsequent investigations were carried out with various dilutions of this standardised suspension.

Results of Investigation: (4/1/39).

Plates were exposed for two hours.

Plate		Number of Colonies.
1	in the W.C. showed	259
2	" " Sister's Room showed ...	22
3	at Bed No. 1 showed	150
4	" " " 5 "	230
5	" " " 10 "	514
6	" " " 11 "	588
7	" " " 16 "	201
8	" " " 20 "	Broken.
9	on So. Fireplace "	163.

The numbers of colonies on the plates were too high for convenient counting, and furthermore they did not represent anything like the far lower numbers of haemolytic streptococci found in a similar experiment in which blood-agar plates were used.

The above figures bear out the previous statement that the south end of the ward contained the highest number of organisms.

The above investigation was repeated under similar conditions on the following day. The results were as follows:-

Plate		No. of colonies found.
1	in the W.C.	145
2	" " Sister's Room	47
3	at bed No. 1	94
4	" " " 5	140
5	" " " 10	210
6	" " " 11	241
7	" " " 17	103
8	" " " 20	106
9	on So. fireplace	152
10	in E. side ward (door closed)	4.

The previous Investigation was repeated on 6/1/39.

The conditions were similar to those mentioned before. In this investigation the "full strength" suspension of B. prodigiosus was diluted 1 in 8.

The results were:-

Plate		No. of colonies found
1	in the W.C.	4
2	" Sister's Room	1
3	at bed No. 1	8
4	" " " 5	38
5	" " " 10	51
6	" " " 11	74
7	" " " 16	25
8	" " " 20	10
9	on So. fireplace	48

This dilution of B. prodigiosus was regarded as suitable for all further investigations.

I N V E S T I G A T I O N VI.

CONCENTRATION OF ORGANISMS IN VARIOUS PARTS OF THE WARD.

This investigation was done in three stages: (6/1/39)

(1) At the head of each bed and in other parts of the ward and its annexes there were placed numbered agar plates. These were not opened until after the organisms were sprayed into the air. The spraying was carried out from the head end of each bed. The atomiser was held at the level of the patients' heads and two puffs given in the direction cough droplets would normally travel.

The first stage of the investigation was carried out in an average ventilated ward, in which only a number of the windows were partly opened for a distance of about 1 foot. This was the state of ventilation in most of the Scarlet Fever wards at the time this investigation was being undertaken.

(2) The second stage of the investigation was carried out in a poorly ventilated ward. In this case only a few of the hopper windows were opened. The unoccupied Ward 19 was used for this purpose.

(3) The third stage of the investigation was performed in a well ventilated ward. (Ward 19a - unoccupied). In this case all the windows and hoppers were opened and the doors left ajar.

(In all cases the spraying was first completed as quickly as possible before the plates were opened. This was done, commencing with the plate where the spraying was started.)

Plate.	Place of exposure.	No. of cols. Average Ventilation	No. of cols. Poor Ventilation	No. of cols. Good. Ventilation
1	At bed 1	11	23	0
2	" " 2	16	20	3
3	" " 3	24	56	0
4	" " 4	20	41	8
5	" " 5	31	78	10
6	" " 6	21	101	9
7	" " 7	29	91	3
8	" " 8	31	142	6
9	" " 9	37	114	3
10	" " 10	45	393	1
11	" " 11	88	430	3
12	" " 12	55	93	5
13	" " 13	44	116	8
14	" " 14	56	87	10
15	" " 15	53	74	13
16	" " 16	31	56	0
17	" " 17	22	125	6
18	" " 18	24	98	3

Plate.	Place of exposure.	No.of cols. Average Ventilation	No.of cols. Poor Ventilation	No.of cols. Good Ventilation
19	At bed 19	19	147	0
20	" " 20	12	23	7
21	Sister's Room	1	18	0
22	West Side Ward	7	6	0
23	East " "	1	10	0

This investigation showed the marked difference in the degree of contamination of the air in poorly and well ventilated wards. Although the figures under "Average Ventilation" are higher than the haemolytic streptococcal figures found in the same ward, the figures in the other two columns indicate the important part played by ventilation in the decontamination of the wards.

I N V E S T I G A T I O N VII.

CROSS CONTAMINATION OF THE CUBICLES FOR ISOLATION IN THE CITY FEVER HOSPITAL.

Construction of Cubicles:

An open ward at one time, the cubicles have been built in it. A centre passage runs the length of the ward. On either side of this a number of cubicles have been constructed. There are fifteen of these, excluding the sun-room.

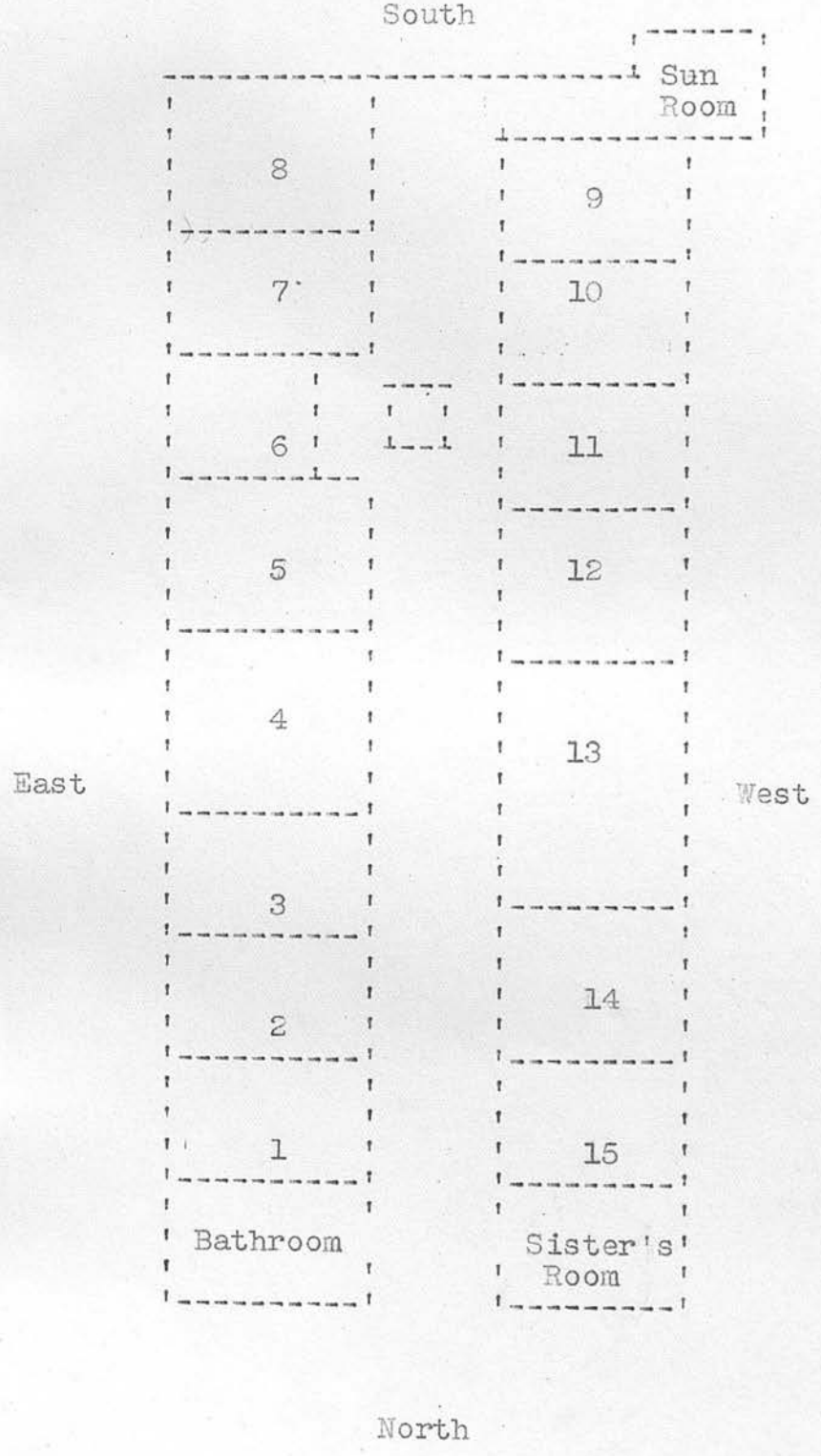
Each cubicle has the following construction: built up from the ground to a height of about four feet is a wooden partition. From this point up to a distance about two feet from the ceiling is glass. There is free ventilation above the glass from cubicle to cubicle.

Since the partitions between the cubicles were not carried right up to the roof, it was assumed that cross-contamination could possibly occur via this route. To prove or disprove this the following investigation was carried out:

In one or more of the cubicles B. prodigiosus was sprayed and agar plates exposed in all the cubicles. The plates were left for 1¾ hours and then incubated.

The following diagram gives a rough plan of the cubicles. The numbers in red refer to the plates.

Plan of Cubicle Ward



(a) More than one Cubicle Sprayed.

Wind ... direction: S.S.W. Velocity ... 4 (Beaument Scale). Cubicle 2 had its outside door open. The wind blew in freely through the window of cubicle 13. Cubicle 9 had its windows widely open; the other cubicles only had their windows partly open.

Results:-

(In cubicles 9 and 13 B. prodigiosus was heavily sprayed.)

No. of Plate.	No. of colonies.
1.	44
2.	12. (Open door)
3.	688
4.	528
5.	240
6.	368
7.	18
8.	860
9.	4,500 (Sprayed here)
10.	447
11.	312
12.	334
13.	(Approx.) 5,000 (" ")
14.	372
15.	117
Bathroom.	28
Sister's Room	250
Passage (South end)	2,200
On Grate (" " of passage)	1,100.

---

(2) Only One Cubicle Sprayed. (4/1/39)

In this investigation only Cubicle 15 was sprayed.

Wind ... the direction was W.S.W. Velocity ... Low, (the wind causes the smoke to just move away from the chimney head).

Results:

No. of Plate.	No. of Colonies.
1.	3,360
2.	546
3.	430
4.	175
5.	36
6.	36
7.	19
8.	104
9.	19
10.	10
11.	22
12.	40
13.	218
14.	534
15.	10,000 (Approx.)
Bathroom.	89
Sister's Room.	30
Passage (south).	63
Grate (")	27.

In the investigation where two cubicles were sprayed, it is seen that severe cross-contamination occurred. The number of colonies was least in cubicles 1, 2 and 7. Since cubicle 2 had its outside door open this probably accounted for the low number of organisms found. The low number in cubicle 1 is probably explained by the fact that the air had to pass cubicle 2 to reach it, and as it took the path of least resistence and blew out of the open door, cubicle 1 escaped much contamination. No reasonable explanation for the low number of colonies in cubicle 7 can be found.

The second part of the investigation reveals a very interesting fact, namely, that cross contamination occurs against the direction of the outside wind. The probable explanation is that the air on entering on the west side of the cubicles is dispersed in all directions by the baffle action of the inter-cubicle partitions.

Although the figures in this second part of the investigation appear formidable, when the dilutions of the organisms in the various cubicles are worked out the results appear less important.

Dilution of orgs. in cubicle 1 ... 1/3.
" " " " " 2 ... 1/18.
" " " " " 3 ... 1/23.
" " " " " 4 ... 1/57
" " " " " 5 ... 1/278

Dilution of orgs.	in	cubicle	6	...	1/278.
"	"	"	"	"	7	...	1/526.
"	"	"	"	"	8	...	1/94.
"	"	"	"	"	9	...	1/526.
"	"	"	"	"	10	...	1/1000.
"	"	"	"	"	11	...	1/455.
"	"	"	"	"	12	...	1/250.
"	"	"	"	"	13	...	1/46.
"	"	"	"	"	14	...	1/19.
"	"	"	"	"	15	...	1.
"	"	"	in	Bathroom		...	1/111.
"	"	"	"	Sister's R.		...	1/333.
"	"	"	"	Passage (S)		...	1/154.
"	"	"	"	Grate (S)		...	1/370.

Although these fractions show that the dilutions of the organisms in many of the cubicles is very great, the fact must not be forgotten that the numbers of virulent organisms as well as virus coughed into the air by a patient in a cubicle, may, within the course of 24 hours, greatly decrease this fraction. This would cause a serious risk of cross-infection.

The main conclusion arrived at from this investigation is that the construction of the cubicles is inadequate and does not prevent cross-contamination of the various units.

I N V E S T I G A T I O N VIII.

DECONTAMINATION OF WARDS BY VENTILATION.

The object of this investigation was to determine how long it took for air to blow the organisms out of the wards.

Three wards were chosen for this investigation (unoccupied). The one was well ventilated - all the windows and doors were opened. The second was poorly ventilated - only a few of the hopper windows were opened. A third ward was given average ventilation - most of the windows were partly opened in addition to the hoppers.

Each ward was investigated in the following manner: Four plates were exposed in those parts of the ward which previous investigations had shown to be the most heavily contaminated. Two plates were therefore placed at the South end of the ward, one just south of the centre on the East side, and one in the middle of the ward. Thereafter B. prodigiosus were blown into the air. (Two puffs with the atomiser at the head-end of each bed.) The plates were opened after five minutes. A fresh set of four plates were laid alongside these and opened after 10 minutes. Similarly plates were exposed after 15 minutes, 25 minutes, etc., up to three hours.

The results obtained were as follows:-

Poorly Ventilated.	Average Ventilation.	Good Ventilation
After 5 minutes:	After 5 minutes:	After 5 minutes:
Plate 1 - 54 orgs.	Plate 1 - 38 orgs.	Plate 1 - 0 orgs.
" 2 - 79 "	" 2 - 19 "	" 2 - 0 "
" 3 -101 "	" 3 - 74 "	" 3 - 1 org.
" 4 - 22 "	" 4 - 43 "	" 4 - 0 "
After 10 minutes:		
Plate 1 - 89 orgs.	" 1 - 15 "	" 1 - 0 "
" 2 - 43 "	" 2 - 24 "	" 2 - 0 "
" 3 - 13 "	" 3 - 53 "	" 3 - 0 "
" 4 - 63 "	" 4 - 35 "	" 4 - 0 "
After 15 minutes:		
Plate 1 - 29 orgs.	" 1 - 8 "	" 1 - 0 "
" 2 - 24 "	" 2 - 12 "	" 2 - 0 "
" 3 - 42 "	" 3 - 24 "	" 3 - 0 "
" 4 - 95 "	" 4 - 26 "	" 4 - 0 "
After 20 minutes:		
Plate 1 - 25 orgs.	" 1 - 9 "	" 1 - 0 "
" 2 - 21 "	" 2 - 7 "	" 2 - 0 "
" 3 - 53 "	" 3 - 11 "	" 3 - 0 "
" 4 - 38 "	" 4 - 6 "	" 4 - 0 "
After 25 minutes:		
Plate 1 - 36 orgs.	" 1 - 8 "	" 1 - 0 "
" 2 - 19 "	" 2 - 6 "	" 2 - 0 "
" 3 - 39 "	" 3 - 4 "	" 3 - 0 "
" 4 - 37 "	" 4 - 2 "	" 4 - 0 "

Poorly Ventilated.	Average Ventilation.	Good Ventilation
After 30 minutes:-		
Plate 1 - 23 orgs.	Plate 1 - 2 orgs.	Plate 1 - 0 orgs.
" 2 - 42 "	" 2 - 0 "	" 2 - 0 "
" 3 - 13 "	" 3 - 5 "	" 3 - 0 "
" 4 - 21 "	" 4 - 1 "	" 4 - 0 "
After 45 minutes:-		
Plate 1 - 22 orgs.	" 1 - 0 "	" 1 - 0 "
" 2 - 15 "	" 2 - 1 "	" 2 - 0 "
" 3 - 24 "	" 3 - 0 "	" 3 - 0 "
" 4 - 12 "	" 4 - 0 "	" 4 - 0 "
After 1 Hour:-		
Plate 1 - 16 orgs.	" 1 - 0 orgs.	" 1 - 0 orgs
" 2 - 9 "	" 2 - 0 orgs.	" 2 - 0 orgs.
" 3 - 3 "	" 3 - 1 org.	" 3 - 0 "
" 4 - 18 "	" 4 - 0 "	" 4 - 0 "
After 2 Hours:-		
Plate 1 - 5 orgs.	" 1 - 0 "	" 1 - 0 "
" 2 - 7 "	" 2 - 0 "	" 2 - 0 "
" 3 - 11 "	" 3 - 1 "	" 3 - 0 "
" 4 - 5 "	" 4 - 0 "	" 4 - 0 "
After 3 Hours:-		
Plate 1 - 6 orgs.	" 1 - 0 "	" 1 - 0 "
" 2 -10 "	" 2 - 0 "	" 2 - 0 "
" 3 - 8 "	" 3 - 0 "	" 3 - 0 "
" 4 - 7 "	" 4 - 0 "	" 4 - 0 "

After 24 hours:-

Plate	1 - 0	orgs.	Plate	1 - 0	orgs.	Plate	1 - 0	orgs
"	2 - 0	"	"	2 - 0	"	"	2 - 0	"
"	3 - 2	"	"	3 - 0	"	"	3 - 0	"
"	4 - 0	"	"	4 - 0	"	"	4 - 0	"

This investigation showed that:

(1) In a very well ventilated ward practically all the organisms were blown out of the ward within the first five minutes.

(2) After 45 minutes a ward with average ventilation had become almost free of the organisms. This ventilation is about that which is given to the scarlet fever wards during the winter months.

(3) After three hours appreciable numbers of the organisms were still to be found in the ward with poor ventilation. Even after 24 hours two colonies were found.

In a well ventilated ward it may be taken therefore, that no sooner are the organisms in the air than they are carried out of the windows and doors.

I N V E S T I G A T I O N IX.

DIMINUTION OF AIR CONTAMINATION BY WET SWEEPING.

Since it was seen that the highest incidence of streptococci in the air occurred during the hours 7-9 a.m. it was assumed that sweeping played some part in the production of this state of affairs. The matter was investigated from the following aspects:

On 10/1/39 two empty wards were heavily sprayed with B. prodigiosus. All the windows had been closed. The wards were then closed and left for three days.

On the 4th day a number of plates were exposed in different parts of the wards for four hours. In doing so an attempt was made to disturb as little as possible the air, floor, etc., and to allow no gush of wind into the wards.

Six of the eight showed no B. prodigiosus. The other two plates had 2 and 4 colonies respectively.

In the one ward the floor was vigorously swept and as much of the dust which had accumulated disturbed. A number of plates were then exposed in various places.

In the other ward a few pounds of moist sawdust was sprinkled on to the floor and then swept. Plates were similarly exposed.

The results of these two investigations were as follows:

	Dry Sweeping. No. of cols.	Wet Sweeping. No. of cols.
Plate 1:	42	13
Plate 2:	64	10
Plate 3:	128	8
Plate 4:	18	11

From these results it is evident that wet sweeping was of benefit in reducing the amount of air contamination. It did not completely prevent organisms entering the air, but a comparison of the numbers shows that a large proportion of the organisms are prevented from rising into the air by the use of wet sawdust.

(This problem is still under investigation - 9/4/39.)

A D D E N D A .

(20/3/38)

INVESTIGATION INTO THE PROBLEM OF TYPING GRANULAR STRAINS.

500 cc. of broth culture was inoculated with a granular, untypable strain, and incubated for 18 hours. The organisms were separated by centrifugalisation. The deposit was washed in normal sterile saline. Five granular strains were treated in this manner.

(1): 0.5 cc. of absorbed type specific serum was placed in a test tube. To the same tube was added a similar quantity of each of the other type specific sera.

To this pooled serum was added the washed organismal deposit and incubated for one hour in a water bath at 37° F. It was then left at room temperature for 2 hours.

If the unknown strain belonged to one of Griffith's 30 types, it was assumed that this procedure would remove the corresponding type specific serum from the pooled serum.

The treated serum was then tried out on suspensions of Griffith's 30 types by the slide agglutination method. The following result was obtained with the first granular strain:

Pooled serum plus Type 1 - Strong agglutination.
" " " " 2 - Weak "
" " " " 3 - " "
" " " " 4 - No "
" " " " 5 - " "
" " " " 6 - Strong agglutination.
" " " " 7 - Weak "
" " " " 8 - No "
" " " " 9 - No "
" " " " 10 - Weak agglutination.
" " " " 11 - " "
" " " " 12 - No "
" " " " 13 -
" " " " 14 - Weak "
" " " " 15 - " "
" " " " 16 - " "
" " " " 17 - No "
" " " " 18 - " "
" " " " 19 - " "
" " " " 20 - doubtful agglutination.
" " " " 21 - No agglutination.
" " " " 22 - Strong agglutination.
" " " " 23 - No "
" " " " 24 - Weak agglutination.
" " " " 25 - " "
" " " " 26 - " "
" " " " 27 - " "
" " " " 28 - No agglutination.
" " " " 29 - Strong agglutination
" " " " 30 - No agglutination.

Since twelve of the organisms would not agglutinate it was obvious that over absorption had taken place with a consequent removal of the type specific agglutinating power of the twelve sera. It was thus decided to add a smaller quantity of the granular deposit of the next unknown strain to a fresh tube of pooled sera.

(2) The deposit of a 150 cc of broth culture of the strain to be typed was added to the pooled serum and treated as before. The results were as follows:-

Treated serum plus type 1 - No agglutination.

" " " types 2-30 - Strong and weak agglutination.

This showed that the unknown strain was Type 1.

(3) The third granular strain was shown also to belong to Type 1.

(4) The fourth granular strain was shown to belong to Type 9. It had come from a patient with tonsillitis.

(5) The fifth granular strain was shown to belong to type 4.

(6) The first strain was again tried out and the treated serum was found to agglutinate all thirty types. In this case therefore it was assumed that a new type was being dealt with. Whether this is definitely the case cannot be stated with any certainty, since there is the possibility that all the type specific serum had not been removed, presuming that

the organism in this case belonged to one of Griffith's 30 types. In such a case agglutination with all thirty types would still occur.

By this method four untypable strains out of five were typed.

Up to this point the investigation had only been carried out with granular strains. There remained the fairly large percentage of untypable strains which gave fine suspensions.

Two of these were taken for investigation and treated in a similar manner to the method just described.

The results were as follows:-

1st strain - No type.

2nd " - Type 3.

To the "no type" strain may apply the same argument as for the first strain of the granular group.

The whole investigation brings out the important point that the majority of untypable strains can be typed and for the most part fall into the class of common types.

It is unfortunate that this investigation could not be carried further. The laborious method it entails makes it impracticable for general usage. The amount of antisera required and the labour spent in absorbing them can be fully appreciated. (This investigation exhausted the stock supply of none of the specific antisera prepared earlier in this research.

The time spent in preparing sera from rabbits must also, therefore, be taken into account if this method is to be adopted as routine.)

C O N C L U S I O N S .

The typing of all the strains of haemolytic streptococci which are pathogenic to man is still a problem of considerable difficulty. Why this is so is due to two facts: Firstly there are a number of strains encountered which fail to produce homogeneous suspensions, but give rise to granular growths, which are totally unsuitable for the slide agglutination method of typing. Secondly a number of strains are met with which produce suitable suspensions, but fail to agglutinate with any of the type specific sera obtained from rabbits, by the injection of vaccines prepared from the thirty strains of type specific haemolytic streptococci isolated by Dr Griffith.

It has been found that the former difficulty can partly be overcome by suitable cultural methods. Such methods take into account two factors - the media for growing the organisms in, and the period of incubation of the cultures. The media generally used, with certain modifications, are those specified by Griffith (1934). He advocated that in testing an unknown strain it is customary to take colonies from primary plate cultures and to make subcultures in each of the following three media: (1). Plain trypsinised meat broth. (2) The same broth with 5% serum (bovine or horse). (3) The same broth with 5% ascitic fluid.

He mentions further that plain broth cultures are more sensitive to the action of agglutinating sera and more liable to grow in a granular fashion than ascitic broth cultures.

The methods laid down by Griffith were originally adhered to in this investigation, but it was found that certain modifications were advantageous in dealing with large numbers of strains. Instead of employing three media for the organisms, they were first put up in only one, namely, a modification of Okell's digest for streptococci, to which had been added 3% of ascitic fluid. With this medium 51% of cultures showed fine suspensions.

All the granular strains were thereafter cultured in three media, viz.: ordinary broth, rabbit serum broth, and pure ascitic fluid. By these means 93% of cultures were rendered suitable for typing.

In agreement with Griffith's (1934) observation, it was found that although the ascitic-broth medium gave the best cultural results, it gave the highest percentage of homogeneous suspensions which could not be typed. As in the case of the granular strains these homogeneous untypable suspensions were also subcultured in the three media mentioned before, and again tried out with the type-specific sera. The fact that an appreciable proportion of the "fine suspensions" could not be typed may have been due to two causes - either new strains were being dealt with

or else by frequent subculturing they had lost their type specificity.

The heaviest growths were obtained in pure ascitic fluid, but they were for the most part highly granular. It appears, therefore, that the addition of excess of broth modifies this tendency. On the other hand the ascitic fluid, which was all obtained from one patient, may have possessed agglutinating powers, apparently only when the fluid was used undiluted or in high concentrations.

The second point in the preparation of suitable suspensions, namely the time factor, has been shown to be of the utmost importance. After the growth has reached a certain stage it readily becomes granular if it is left at 37° C. It is, however, found that if the cultures are removed from the incubator the moment a fairly marked haze appears in the medium, and is left at room temperature for 18 to 24 hours, this tendency to granular growth does not advance as rapidly; and that it apparently enhances the type specificity of the organisms. The time taken for the organisms to reach a suitable stage for removal from the incubator was found to be for the most part 6-9 hours. This time is longer the smaller the inoculum. A heavy inoculum is therefore the most suitable.

In the preparation of the specific sera for agglutination purposes, it has been found that the more rapidly the rabbits are immunised, the less

group agglutinin is there produced in the serum. This, however, is not always practicable, because frequently, if the increase of the doses of the vaccine is too rapid, the rabbits lose weight and die. The best criterion to adopt for this increase was found to be the general condition of the rabbits, based on weekly weighings. The moment a loss of weight was recorded, the injections were withheld.

Periodic test bleedings during the process of immunisation are necessary to ascertain when a sufficiently high titre of the serum has been reached.

It is best to reject sickly or small, thin rabbits and commence afresh with brown, healthy ones. It may here be observed that frequently the sera may be found to give specific reactions after as few as three or four injections, but such sera when absorbed or diluted tend to lose their type-specific agglutinating powers.

The usual time taken to produce a satisfactory serum is about six or seven weeks.

The method of rendering the specific serum suitable for agglutination purposes differed slightly from that described by Griffith (1934). It was found that the addition of serum, drop by drop, to a known quantity of saline, until the specific reaction was quite definite, rendered the group agglutinin inert in a number of cases. It was therefore unnecessary to absorb all those sera, which before dilution showed cross-reactions.

It has been found by a number of investigations that a large proportion of those strains, normally not typable, belong to the same types as the common epidemiological strains prevailing at any particular time.

The method employed to prove this point was to mix the unknown strain with the thirty type-specific sera pooled. This was then tried out for its agglutinating powers on the suspensions of Griffith's thirty types. That type which did not agglutinate was taken to be the same as the unknown strain, on the assumption that it had removed from the pooled sera that particular serum to which it corresponded.

This investigation proved its impracticability for the routine examination of untypable strains. Its importance, however, lies in the fact that most of the strains typed proved to be common ones, and that the conclusions of any investigation, in which a large number of haemolytic streptococci are to be typed, would not be materially affected by the low percentage of completely new strains encountered.

If the figures obtained from this investigation are correct then approximately 94% of all strains encountered belong to Griffith's thirty types. It is, however, evident that a larger number of strains will have to be investigated to determine the validity or otherwise of this general statement.

The number of days spent in hospital by cases of scarlet fever showing complications, in excess of the average, during the period September, 1937, to November, 1938, was 14,400 days. This additional burden to the hospital authorities must undoubtedly be a heavy one. These figures immediately show the importance of a more comprehensive study of the underlying causes of scarlet fever complications.

How these complications arise depend on a number of causes. First and foremost of these is cross-infection with new strains of haemolytic streptococci. 61.5% of all complications are due to types differing from those with which the patients were admitted to hospital. Secondly, 20.2% of complications are due to types the same as those found when the patients entered the wards. 10.8% of complications arise from untypable strains; and lastly, 7.5% of complications are due to other organisms.

It is difficult to determine, without laborious investigation, to which of the first two groups the majority of untypable strains belong. Since it has been shown that in all probability the majority of untyped strains belong to one or other of Griffith's thirty types, it may be reasonable to suppose that they will follow the same percentages as the typed strains.

Since the bulk of the complications are due to cross infection with new types, this is the problem which deserves our most serious consideration. The

haemolytic streptococcus may be conveyed from patient to patient by one of four methods - by direct contact, by indirect contact, by fomites and food, and lastly by the air (which includes droplet infection).

That direct contact plays an important part in the transmission of the streptococcus is undoubtedly the case, for it is found that a large number of complications arise only after the patients have been allowed up.

The average times which elapse before the various complications arise, are as follows:-

Adenitis	.....	11.7 days.
Rhinitis	.....	14.4 days.
Otorrhoea	.....	13.8 days.
Arthritis	.....	7.8 days.
Nephritis	.....	18.3 days.
Peritonsillar abscess.		6.1 days.
Vaginitis	.....	19 days.
Myositis	.....	5 days.
Pyrexia	.....	15.1 days.

These figures are somewhat misleading since it is found that the highest incidence of complications occur during the 5th, 6th, and 7th days in hospital. The following table will bring out this point.

Out of 282 complications there occurred during the 1st day .... 1 complication.

2nd " ....10 complications.

3rd " ... 31 "

4th	day	 11	complications.
5th	"	 26	"
6th	"	 23	"
7th	"	 16	"
8th	"	 18	"
9th	"	 9	"
10th	"	 9	"
11th	"	 12	"
12th	"	 14	"
13th	"	 8	"
14th	"	 7	"
15th	"	 11	"
16th	"	 5	"
17th	"	 9	"
18th	"	 5	"
19th	"	 5	"
20th	"	 5	"
21st	"	 11	"
22nd	"	 4	"
23rd	"	 6	"
24th	"	 5	"
25th	"	 7	"
Over the 25th	"	 24	"
		282	"

It will be observed that of the 282 complications, 126 occurred from the 1st to the 8th day, and 185 by the end of the second week. Thus by the time

the average patient is allowed up far more than half the complications have already occurred.

It appears likely that a proportion of the 97 complications which occurred after the second week must have been the result of contact. That they were solely due to contact is not the case, for it was shown that a number of convalescent patients, who were running about the ward, contracted complications almost simultaneously with type 6, whereas the only source of infection in the ward at that time was a cot-patient with rhinitis.

To reduce contact-complications is a very difficult problem for it is wellnigh impossible to prevent the intercourse of children once they are up. Some suggestions will however be offered presently which may be of some use in preventing cross-infection.

From this investigation, the majority of complications appear to be due to air-borne infection. That large numbers of haemolytic streptococci are to be found in the wards of scarlet fever cases (the air) was shown to be the case. Their numbers depend largely on ventilation. The south end of the wards, where the organisms are found in greatest numbers, and where the largest number of complications occur, was found to be adequately cleared of organisms by opening the door of the fire-escape and partly the large balcony door and windows. These for the most part are closed during the winter months.

In order to reduce the number of complications among scarlet fever patients, the following suggestions are offered:

(1) Reduction of Streptococci in the Air.

(a) Since the south end of the wards is particularly implicated, ventilation in that part should be increased. This could be done by opening the south windows further and placing the fire-escape and balcony doors ajar.

(b) The four south end beds should be the last to be occupied, when the number of admissions permit of this.

(c) Wet sweeping and dusting of the floors and furniture was shown to reduce the number of organisms in the air. This practice would, therefore, tend to reduce air contamination with haemolytic streptococci.

(d) The north doors should never be closed. This would assist in a better removal of the organisms by the air, considering the fact that the prevailing wind is from the west south west.

(2) Control of patients.

(a) All cases with severe cough or rhinitis should be isolated in a separate ward or in cubicles as far as is practicable, or should be placed at the north end of the wards where ventilation is better. It was shown that otorrhoea cases did not produce as much cross-infection as patients with rhinitis.

(b) No cases showing complications should be allowed to mingle with "clean" convalescents. If the former were confined to their beds this danger would be reduced.

(c) On being allowed up all cases should be removed to the ward above. This will prevent late cases coming in contact with early ones, and so reduce the risks of cross-infection.

(d) Since the above methods will prevent the contact of early and ambulant cases, it will be possible to prevent toys being promiscuously handled by those patients still confined to their beds.

It has been shown that toys may prove to be a real source of danger.

The ideal method of treatment would be the isolation of every patient. This, however, is impracticable under present conditions. The above methods would undoubtedly be less satisfactory, but even though they would incur extra work, they could be carried out during periods when no serious epidemics fill the wards, as was the case in the winter of 1937. Even if they reduce the complication rate by 10 or 20 per cent, the additional labour and expense would be justified.

The methods put forward to reduce cross-infection are by no means comprehensive and detailed; to do so would make them too cumbersome for practical application.

Although the complications in scarlet fever patients were the main object of this investigation, an attempt was made to show what correlations existed between the various epidemic and endemic streptococcal infections. Certain correlations were found to exist.

It was seen that the majority of strains present in scarlet fever, erysipelas, mastoiditis, and otitis media, tonsillitis, puerperal fever and normal throats, were of the same types at any particular periods.

This fact shows that the same types of streptococci, 1 and 4 for example, may cause all the lesions associated with streptococcal infection. This was early realised in the work. In addition however it was seen that certain streptococcal diseases were associated with certain types not commonly found in other conditions. Thus, in addition to types 1 and 4 being found in all the diseases, type 13 was associated only with puerperal fever, type 7 only with erysipelas, type 18 particularly with tonsillitis, type 17 with rheumatic fever and type 28 with enteritis. In healthy throats types 7 and 20 were particularly common.

Whether these figures indicate any selectivity on the part of the haemolytic streptococci, is a problem that requires further investigation.

This shows the extent to which certain types of streptococci spread through an urban community such as exists in Edinburgh. It further indicates the

vastness of the problem of controlling the spread of infection.

The fact that carriers of the epidemiological types exist during such periods increases the difficulty.

In schools small outbreaks of scarlet fever due to the same types were found to occur. This would indicate that at such times carriers are present who spread the infection. To swab all school children during epidemic periods is an almost impossible task, but it appears to be the only means of isolating such carriers. In small primary schools such an investigation may prove beneficial in discovering where the source of infection lies.

Although the mildness of scarlet fever at present does not warrant any such comprehensive procedure, the high complication rate deserves serious attention. Wholesale immunisation of pupils on admission to school appears to be the only means at present available, of reducing the occurrence of such complications. This is a public health problem and beyond the scope of this investigation.

It has been shown that the time various types of haemolytic streptococci remain in the throat of a healthy immune person, repeatedly exposed to streptococcal infection, is usually of only a few days duration, whereas the organisms often remain for long periods in the throats of patients recovering from the diseases it produces.

This observation shows that certain prophylactic steps are advisable, namely, to swab repeatedly cases recovering from haemolytic streptococcal disease before they are allowed free intercourse with other members of the community. It was shown that swabs may become positive after four negative ones (p. 62). At least this number should, therefore, be taken on successive days before a decisive "free of infection bill" is granted.

If this procedure cannot be adopted in the hospital then general practitioners should be encouraged to do the swabbing whilst the patients remain in quarantine at home. By these means at least a proportion of the number of return cases would be prevented.

During the winter months, when streptococcal infections are numerous and ventilation is inadequate, it was shown that the air of crowded places, such as picture houses, buses, trams, shops, etc. is heavily contaminated with haemolytic streptococci.

The conclusion drawn from this observation is that susceptibles should as far as possible avoid such places in order to diminish the risks of infection. This is not always possible. A prophylactic measure which may be beneficial is that of nasal douching and gargling after having been in such places. The effect of such measures is still being investigated.

Certain types of streptococci were found to be more pathogenic than others, although not always as invasive. Thus it was found that types 4 and 28 were more likely to produce complications in scarlet fever than type 1, which proved to be comparatively mild in the clinical manifestations it produced.

The sudden rise during May of 1938 of the complications expressed as a percentage of the total number of admissions to the City Fever Hospital is seen on the monthly graph of complications following page 35.

55% of admissions during that month developed complications. Type 28 was shown to be the cause of this sudden increase. This indicates the high pathogenicity that type may possess.

The term "may possess" is used for it appears that certain types may increase or decrease in virulence. This is based on the fact that early in the investigation type 28 occurred in the ward without giving rise to any sporadic outburst of complications due to that type.

The steady decline in the graph during September, October and November, 1938, despite the fact that most of the admissions were due to type 4, as were also the complications, may or may not depend on such an attenuation of virulence. On pages 96-7 an explanation for this phenomenon was attempted.

It appears that cases admitted with a virulent type are less likely to develop complications from that type, whereas cases admitted with a strain of low pathogenicity do so more readily. Since most of the admissions during October and November were due to type 4, this may account for the decline of the percentage of complications.

The monthly chart of scarlet fever shows that during an epidemic there is one predominant type of haemolytic streptococcus (vide charts 9 and 10, after page 39), and that as it wears itself out it is replaced by another. What the explanation for this is has not been decided. At sporadic intervals there are outbursts of cases due to other types. Some of these are particularly virulent in their effects.

SUMMARY OF WORK.

(1) Preparation of Type-Specific Sera.

(a) Vaccine was prepared from Griffith's thirty types of haemolytic streptococci.

(b) Rabbits were injected and test-bleedings made at various times to estimate the titre of the serum.

(c) The method of preparing type-specific agglutinating sera was described, and particular mention of cross-reactions was made.

(2) The Typing of Haemolytic Streptococci.

(a) A series of investigations were carried out to determine the most suitable media for growing homogeneous suspensions of haemolytic streptococci.

The method of incubation best suited was described.

(b) A description of the slide-agglutination method of typing used throughout this work was given.

Clinico-bacteriological Investigations of Scarlet Fever Cases.

(3) The procedure adopted in swabbing patients was intimated.

(4) There followed a description of the method adopted for storing haemolytic streptococci "in vacuo".

(5) Statistical records for the period September 1937 to January 1939 were drawn up and included the total number of admissions of scarlet fever cases to the City Fever Hospital, the total number swabbed,

the total number of complications, and the total number of complications swabbed.

(6) Monthly graphs and tables indicating the result of typing the above cases was given.

(7) The monthly percentage increase and decrease of the various types of haemolytic streptococci were recorded.

(8) An investigation was carried out to show whether any difference in the types of haemolytic streptococci found in the throats and noses of scarlet fever cases existed.

(9) The next investigation was carried out to determine whether there occurred more than one type of haemolytic streptococcus in the throat swabs of patients on admission to hospital.

(10) This investigation was an attempt to ascertain whether any cases, which had been in the wards for some time, had more than one type of haemolytic streptococci in their throats.

(11) The results of the last investigation were compared with those found during the first day complications became manifest.

(12) Daily swabs were taken in a single ward over a period of 23 days and all the patients typed. All cross-infections were noted.

(13) The same investigation was carried out over a period of 46 days.

(14) 384 cases showing complications were investigated. The haemolytic streptococci present on

admission and those responsible for the complications were noted. Correlations between types and lesions, etc., were recorded.

(15) An investigation was undertaken showing the decrease of haemolytic streptococci in the throats of patients during their stay in hospital.

(16) During the month of May, 1938, twenty cases of scarlet fever were typed and the same done to fifteen cases showing complications. The results were investigated.

(17) A statistical record of scarlet fever cases occurring in the City of Edinburgh from the 1/9/37 to 31/12/38 was drawn up.

(18) The number of patients per month from the various schools and institutions in Edinburgh was calculated and recorded in tables.

A graph comparing the number of school children with all other cases is given.

(19) The types of haemolytic streptococci found in school cases and other patients were noted and certain correlations observed.

(20) An attempt was made to show that there existed a relationship of types of haemolytic streptococci found in the patients from individual schools.

(21) 54 cases of puerperal fever were investigated bacteriologically.

(22) Similarly 40 cases of erysipelas were investigated.

(23) This was also done with 10 cases of otitis media or mastoiditis, and

(24) with 60 cases of tonsillitis.

(25) A miscellaneous group of diseases sent into the City Fever Hospital as scarlet fever cases was examined for haemolytic streptococci (42 patients).

(26) Eight positive haemolytic streptococci swabs from the Third Year Medical Students were examined. This was carried out during a time when "coughs and colds" were common.

(27) 32 cases of respiratory diseases occurring in a rural area were investigated for the presence of haemolytic streptococci. These were typed and compared with the urban strains.

(28) The next investigation was carried out to ascertain the presence of haemolytic streptococci in normal throats and to find what correlation there existed between the types found and the various streptococcal infections. The normal throats were those of:

(a) 40 nurses from the City Fever Hospital.

(b) The positive swabs from a number of nurses from the Western General Hospital,

(c) Six resident doctors in the City Fever Hospital.

(d) Ten strains from the Third Year Medical students were typed. The period was one when only a few "coughs and colds" were about.

(e) 16 families, from whom cases of scarlet fever had been sent to hospital, were visited and all members swabbed, with a view to determining the presence of haemolytic streptococci and observing any correlations.

(f) This investigation was carried out upon my own person to estimate the number of haemolytic streptococci present in throat and nose before and after contact with scarlet fever patients.

(29) The presence of haemolytic streptococci on toys and food in the scarlet fever wards was investigated.

(30) A similar investigation was carried out on the handkerchiefs of patients.

Air-Contamination with Haemolytic Streptococci in The City Fever Hospital Wards.

(31) (a) A research was made to determine the incidence of haemolytic streptococci in the air of scarlet fever wards.

(b) A similar investigation was done in a puerperal ward; and in

(c) an erysipelas ward; and in

(d) a diphtheria; and in

(e) a measles ward.

(f) The first investigation (a) was repeated in a ward with a high complication rate, and repeated in another with a low complication rate. The results were correlated.

(32) Air contamination with haemolytic streptococci in the Ear, Nose and Throat Department of the Edinburgh Royal Infirmary was investigated.

(33) The next investigation was to determine the presence of haemolytic streptococci and their

types in picture houses, buses, trams, shops and open places.

(34) An attempt was made to correlate the types found in scarlet fever with those of all other streptococcal infections.

(35) A research into the problem of air-borne infection was carried out. The object of this investigation was to determine what effects variations of ventilation, and wet and dry sweeping have on the number of organisms in the air.

B. prodigiosus was the organism used in this investigation and was sprayed by means of an atomiser.

(36) Cross-contamination in the cubicles of the City Fever Hospital was investigated.

(37) The final investigation was an attempt to type those strains of haemolytic streptococci which were either too granular or failed to type by ordinary methods.

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