

NOSOCOMIAL¹ INFECTIONS IN CHILDREN'S WARDS

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(With 2 Figures in the Text)

IN the year 1858, 2831 infants were admitted to the wards of a hospital in Prague. All succumbed, the principal causes of death being gastro-enteritis and "septicaemia". Throughout the European hospitals till late in the nineteenth century a similar tale was told, and parents feared to send their children to these institutions, where "they died, not from the malady for which they entered the hospital, but from that which they contracted therein". To the credit of Rauchfuss (1877), of St Petersburg, and of Grancher (1888) and Hutinel (1894), of Paris, lie the first attempts, towards the end of the nineteenth century, to introduce sanitary measures into children's wards and to provide isolation facilities for the detection of infectious disease among hospital entrants. A marked reduction in mortality ensued, in one hospital, for example, from 40 to 8%. General improvement in public-health measures, resulting in a bacteriologically purer water and milk supply, the realization of the practical implications of the "carrier" as a vehicle of infection, etc., reduced still further the incidence of nosocomial disease, particularly that due to gastro-intestinal infection. But a residual risk remains to-day, particularly with regard to respiratory disease. As McKhann, Steeger & Long (1938) state, "the problem of cross-infection in an infants' hospital is not so much a question of controlling gastro-intestinal and so-called contagious disease as one of preventing acute infections of the respiratory tract and certain ailments of the skin".

Nosocomial disease in children's wards has called forth widespread comment during recent years. In the United States of America, the Third Annual Meeting of the American Academy of Pediatrics in 1933, in Scandinavia, the Sixth Northern Pediatric Congress in 1934, and in Switzerland, the Fourth Conference of the International Association for Preventive Paediatrics in 1935 selected this as the chief subject for discussion. In France, following a paper by Debré to the Académie de Médecine in 1936, a Commission was appointed to make a special investigation regarding cross-infection in children's wards. The Commission, recognizing the seriousness of the problem, advocated that child patients should be nursed in individual cubicles, that strict prophylactic rules for nurses, doctors and students should be enforced, that no visiting

¹ A term applied to diseases caused or aggravated by hospitalization, from Gr. *νοσοκομείον*; L. *nosocomium*, a hospital.

should be allowed and that a medical officer with special experience of infectious diseases should be in charge of a prevention and vigilance service in each paediatric unit. In England the definition of numerous serological types of *Streptococcus pyogenes* by Griffith (1926, 1927, 1934) and the classification of *C. diphtheriae* into *gravis*, *mitis* and *intermediate* types by Anderson, Happold, McLeod & Thomson (1931), Anderson, Cooper, Happold & McLeod (1933) have given greater precision to the epidemiological study of the spread of organisms in hospital wards. In particular may be mentioned the work of Okell & Elliott (1936), Allison & Brown (1937), Keevil & Camps (1937), Bradley (1938) and Glass & Wright (1938) on nosocomial infections.

The investigations here recorded of cross-infection in the children's wards of University College Hospital, London, may therefore be regarded as a local aspect of a general problem of historical and geographical distribution.

SCOPE OF THE INVESTIGATION

The problem of cross-infection in the children's wards first attracted attention by the occurrence of four outbreaks of infection by haemolytic streptococci. These were not discovered as a result of routine laboratory investigation, but compelled attention by reason of the clinical effects produced. Since bacteriological investigation was not started in these wards until some time after the beginning of the outbreaks, the data collected were necessarily incomplete. It was possible in each outbreak, however, to inculcate one serological type of haemolytic streptococcus as the probable infecting agent.

(a) *Type 2 haemolytic streptococcus. Ward B. Sections I and II. September and October 1936*

4 children: 1 admitted for cystoscopy, developed scarlet fever.

1 „ „ wasting, developed scarlet fever.

1 „ „ pyelitis, developed scarlet fever.

1 „ „ bronchitis, developed sore throat.

Type 2 haemolytic streptococci were isolated from the throat swabs of these four children. In addition, one nurse and one other child in these wards developed scarlet fever during this period, but the swabs, which were taken subsequent to their transference to a fever hospital, yielded no haemolytic streptococci.

(b) *Type 1 haemolytic streptococcus. Ward A. April and May 1937*

7 children: 1 admitted for umbilical hernia, developed scarlet fever.

1 „ „ chorea, developed sore throat.

1 „ „ cleft palate, developed pyrexia.

1 „ „ acute nephritis, developed exacerbation of pyrexia.

1 „ „ abscess of neck, from which only *Staph. aureus* grew, developed otitis media and cervical adenitis.

1 „ „ appendicitis, developed latent infection.

1 „ „ wasting, developed latent infection.

Type 1 haemolytic streptococci were isolated from the ear swab of the child who developed otitis media and from the throat swabs of the other six children. In addition during this period two children developed scarlet fever, one developed a sore throat, and another an

infection of a previously clean operation wound. Haemolytic streptococci were isolated from the throat swabs of the first three of these children and from the wound swab of the last, but since the isolations were made previous to this investigation, serological typing was not performed.

(c) *Type 13 haemolytic streptococcus. Ward B. Section I. May and June 1937*

3 children: 1 admitted for tuberculosis peritonitis, developed otitis media and nephritis.
 1 „ „ coeliac disease, developed latent infection.
 1 „ „ fits, developed latent infection.
 2 nurses: 1 developed sore throat.
 1 „ „ scarlet fever.
 1 doctor: „ „ sore throat and later desquamation of hands.
 1 wardmaid: „ „ latent infection.

Type 13 haemolytic streptococci were isolated from the throat swabs of all these persons, and from the ear swab of the child who developed otitis media. In addition during this period two other nurses in this ward developed scarlet fever, but throat swabs were not obtained.

(d) *Type 2 haemolytic streptococcus. Ward B. Sections I and II.¹
 May and June 1937*

3 children: 1 admitted for cough, but had had rash on chest, back and face 2 days before admission.
 1 „ „ „ scabies, developed scarlatiniform rash and later nephritis.
 1 „ „ „ bronchitis, developed sore throat and cervical adenitis.
 1 nurse: developed scarlet fever.

Type 2 haemolytic streptococci were isolated from the throat swabs of all these persons.

The bacteriological data, though incomplete, warranted further investigation on similar lines, and a systematic survey was made in the children's wards of the hospital from September 1937 to September 1938. The detailed bacteriological work was limited to haemolytic streptococci for two reasons—first, the identification by Griffith (1926) of a number of well-defined serological types of haemolytic streptococcus renders it possible to study the introduction and spread of these organisms; and secondly, the haemolytic streptococcus is one of the organisms frequently implicated in ward cross-infections, one and the same serological type producing varied clinical manifestations with or without a scarlatiniform rash.

Notes were also made of outbreaks of diphtheria, dysentery, acute gastroenteritis of infancy and epidemic catarrhal jaundice but special bacteriological work was not undertaken. Such bacteriological notes as are appended were obtained from the routine investigations of the Clinical Pathology Department of the Hospital.

ROUTINE PROCEDURE

On admission and subsequently once weekly, swabs were taken from the patients' throats and from any suppurative lesion found. Throat swabs were taken from the ward nurses once weekly. A daily round of the wards was

¹ I am indebted to Dr S. D. Elliott for his kind permission to publish the results of these outbreaks. His further collaboration in this investigation, for the start of which he was responsible, was prevented by his appointment to duties elsewhere.

made, and swabs were taken from the site of any suspected haemolytic streptococcal infection in patients or nurses. Each swab was plated on horse-blood agar. After 18 hours' incubation at 37° C., one colony of any haemolytic streptococci found was picked into broth and incubated for 18 hr. The deposited growth was tested by the slide-agglutination method against the streptococcal type sera.

WARD ARRANGEMENTS

The following rules governed the admission and care of patients in all the children's wards, but were subject to modification at the discretion of the medical and nursing staff.

1. Children of 14 years of age and under may be admitted.
2. Each child on admission is to be placed in a cubicle or behind a glass screen. The screens are approximately 9 ft. in height and surround the two sides and bottom of the cot.
3. Throat and nose swabs are to be taken on admission and examined for the presence of haemolytic streptococci and *C. diphtheriae*. The resident doctor concerned is responsible for seeing that these are taken and planted out before midnight on the day of admission. The child is not to be removed from the cubicle or screen to the open ward until both swabs have yielded a negative result.
4. All children are to be Schick tested within 24 hr. of admission.
5. Any infectious diseases which the child has already had, and any contact with infectious disease during the month prior to admission, are to be noted.
6. Patients in the open wards are to be placed in a cubicle or behind a screen immediately, and nursed by the isolation technique, if they develop:
 - (a) a sudden marked pyrexia, after being apyrexial;
 - (b) a rash, sore throat or cough.
7. Children suffering from diarrhoea and vomiting are, as far as possible, to be placed in isolation cubicles and handled only by persons wearing gowns and gloves. Boards labelled "Infectious" are to be placed above the cot.
8. The following additional rules apply when nursing patients in cubicles or behind screens:
 - (a) gowns are to be hung in the cubicle or behind the screen, and to be used by everyone touching the child;
 - (b) a fresh mask is to be worn by each such person;
 - (c) hands are to be washed immediately on leaving the patient;
 - (d) a bowl of disinfectant (1% carbolic solution) is to be available for disinfection of hands, stethoscope and other instruments used.
9. No visitors are to be admitted to the children's wards without the consent of the medical member of the staff in charge of the case or of his assistant.

Ward A

This ward consists of three sections (Section I, cots 2-13, for medical patients; Section II, cots 17-24, for surgical patients; and Section III, cots 25-31, also for surgical patients), separated by a central corridor with glass partitions 7 ft. in height. In addition there are four cubicles (cots 1, 14, 15, 16) separated from the other sections by walls from floor to ceiling and from the central corridor by 7 ft. glass screens. The same nursing staff works in all these sections.

The age distribution of the patients in this ward during the year was as follows: 0-2 years, 82; 2-4, 29; 4-6, 62; 6-8, 39; 8-10, 32; 10-12, 42; 12-14, 28.

The following were the details of the ward hygiene:

Blankets, mattresses and pillows remained with the cot after discharge of a "clean case", and bed-linen was laundered. After discharge of a patient with manifest infection, mattresses, pillows and thick blankets were stoved and thin blankets and bed-linen soaked in 2% carbolic solution before laundering.

Cots and bed-mackintoshes were washed with carbolic solution after discharge of the patient.

China and silverware were boiled after each use.

Thermometers were kept in 1 in 6 carbolic solution. Temperatures of infants were taken by rectum; of other children in the axilla or groin.

Books, toys, etc., after being used by "clean patients" remained in ward; after use by patients with manifest infection they were destroyed.

Baths. "Bed-patients" were blanket-bathed, individual blankets being reserved for this purpose. Other children were bathed in general bathroom.

Urinals were washed after use, unless from patient with manifest infection, when they were boiled.

Bed-pans were boiled after each use.

Infants' napkins were scrubbed out by nurses, then sent to laundry. The same nurses dealt with napkins and with feeds.

Infant feeding bottles were boiled after each use; teats were boiled twice daily and reserved in sterile water for individual infants.

Ward cleaning. Floors were cleaned with Electrolux vacuum cleaner; locker tops, slabs, etc., were wet-dusted; otherwise dry dusting was used.

Nurses' duty. In addition to the sister-in-charge, there were two nurses on duty in the morning, three in the afternoon and three at night.

Ward B

This ward consists of two sections, Sections I and II, each with ten cots, separated by a central corridor with walls from floor to ceiling. In addition there are two single-cot cells attached to each section. The same nursing staff works in both sections, which are for medical cases only.

The age distribution of the patients in this ward during the year was as follows: 0-2 years, 93; 2-4, 33; 4-6, 27; 6-8, 32; 8-10, 23; 10-12, 21; 12-14, 8.

The following were the details of the ward hygiene:

Blankets, mattresses and pillows. After discharge of "clean case", the bed-linen and the blanket next to patient were laundered; the mattress, pillows and other blankets remained with the cot. From a patient with manifest infection blankets were laundered, mattresses and pillows were stoved.

Cots and bed-mackintoshes were washed with soap and water after discharge of patient.

China and silverware in general use was boiled once weekly. From a patient with manifest infection it was boiled after each use.

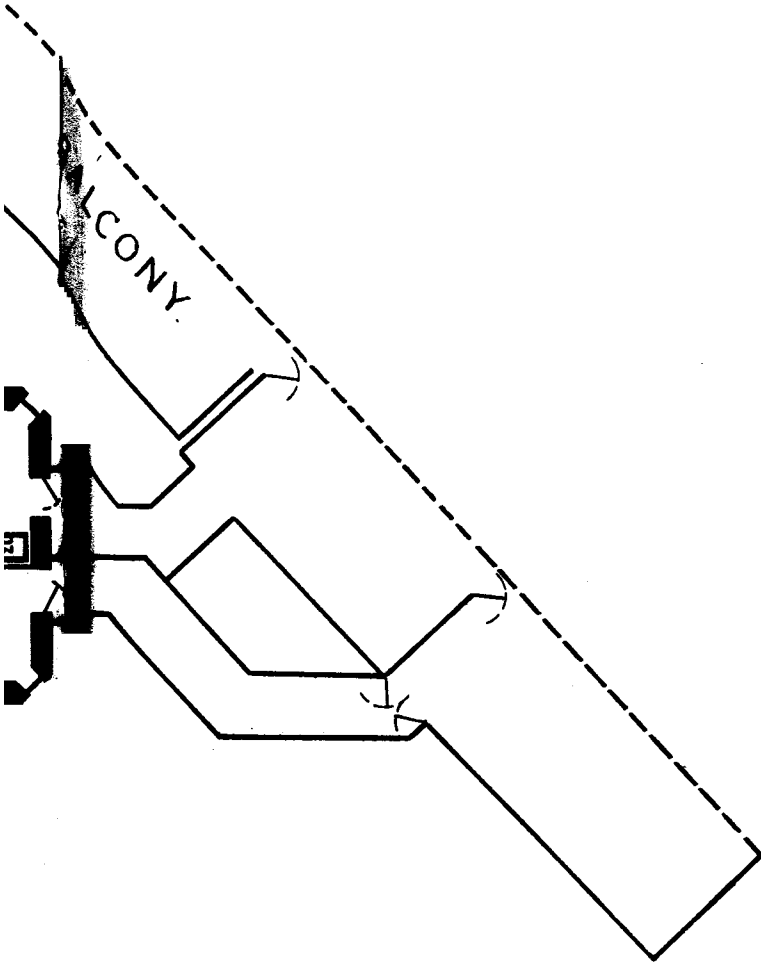
Thermometers were kept in 1 in 6 carbolic solution. Temperatures of infants were taken in groin; of other children in axilla.

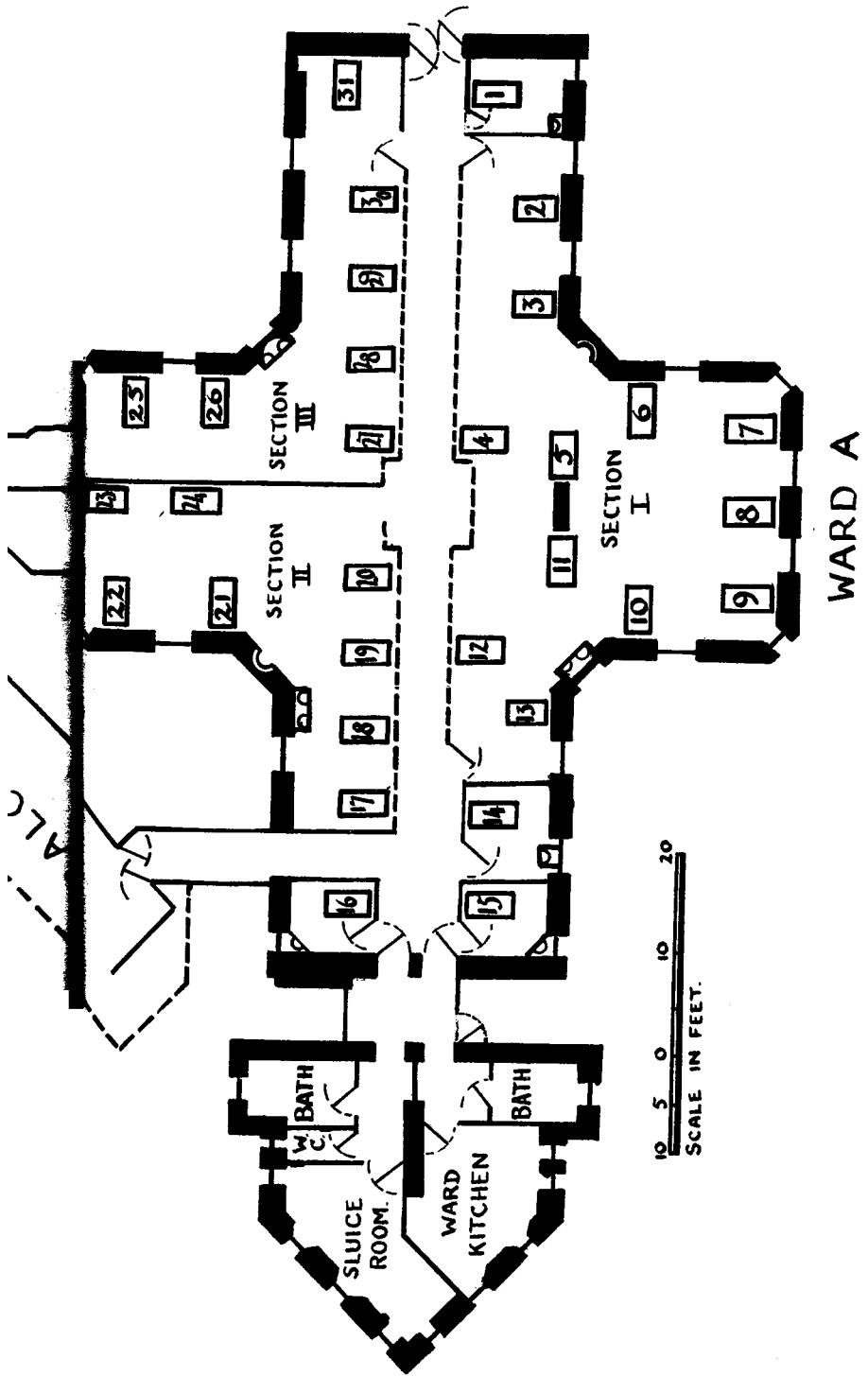
Books, toys, etc., after use by patient with manifest infection were destroyed; otherwise remained in general use.

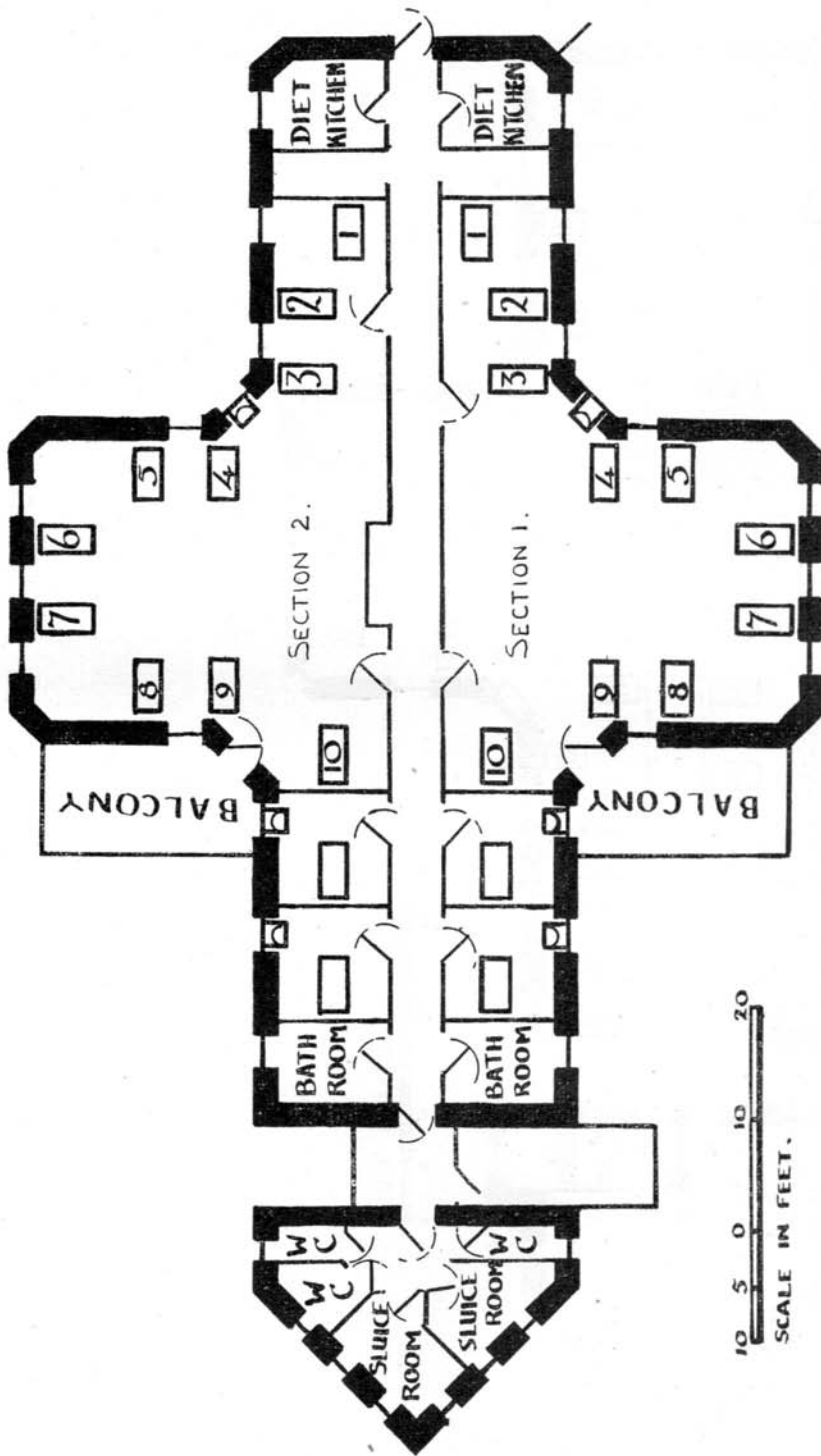
Baths. "Bed-patients" were blanket-bathed, special but not individual blankets being reserved for this purpose. Other children were bathed once daily in general bathroom.

Urinals were boiled once daily.

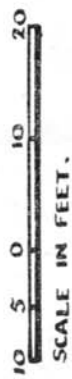
Bed-pans were soaked every night in weak lysol.







WARD B



Infants' napkins were scrubbed out by nurses, then sent to laundry. The same nurses dealt with napkins and with feeds.

Infants' feeding bottles were boiled once daily; the bottles were in general use, but individual teats were kept in sterile water. For infants with gastro-enteritis separate bottles were kept and boiled after each feed.

Ward cleaning. Floors were cleaned with Electrolux vacuum cleaner; dusting with dry duster and feather mop.

Nurses' duty. In addition to the sister-in-charge, there were four nurses on duty from 7 to 10 a.m., 1 to 2 p.m. and 4.30 to 8 p.m.; the rest of the time two only.

RECORD OF RESULTS

Of the 551 patients in Wards A and B during the year of the investigation, at least 104 (or 18.9%) developed intercurrent infection, either latent or manifest, while in hospital. There was not a marked difference in the incidence of nosocomial infection among the patients of the two wards, being 16.9% (i.e. 53 of 314 patients) in Ward A and 21.5% (i.e. 51 of 237 patients) in Ward B.

The detailed reports of the infections, which occurred principally as outbreaks and not as isolated events, are given below. The term "latent infection" has been applied to bacterial infection which occurred without producing clinical manifestations in the patient. Pyrexia has only been noted when it succeeded an apyrexial period and could not be accounted for except by the occurrence of intercurrent infection. When pyrexia occurred over a period of time, the highest temperature and pulse rate reached during that period has been noted. In general the cot positions have not been recorded, since they were frequently changed, and since the children, when on the balconies, came into close contact with cots other than those of their ward neighbours.

Haemolytic streptococcal infection

From the admission swabs of 13 (or 4.1%) of the 314 children of Ward A and of 23 (or 9.7%) of the 237 children of Ward B, haemolytic streptococci were isolated, the type distribution being as follows:

Ward A. One patient, type 1; two, type 2; one, type 4; one, type 6; one, type 8; one, type 12; one, type 27; two, type 28; three, not identified.

Ward B. Two patients, type 1; one, type 3; two, type 7; three, type 8; one, type 9; two, type 12; four, type 25; two, type 28; six, not identified.

Haemolytic streptococcal infection was acquired by 33 (or 10.5%) patients in Ward A and by 39 (or 16.5%) in Ward B during hospitalization.

The following are the detailed records of the haemolytic streptococcal infection amongst the patients and nurses *during their stay in the wards*. The term "negative" has been used to indicate that no haemolytic streptococci of the particular type involved in the outbreak were isolated from a swab.

The period during which the throat swabs of the patients remained positive was variable—in some cases a particular type was isolated on one occasion only; in other cases it recurred intermittently during several months.

I. *Type 25 haemolytic streptococcus. Ward A. February to August 1938*

- i. Male, 9 years: admitted for osteomyelitis.
 - 22. ii. 38. Admission swabs negative.
 - 23. v. 38. Throat swab: type 25 streptococcus.
 Latent infection.
- ii. Male, 4 weeks: admitted for pyloric stenosis.
 - 16. iii. 38. Date of admission. No swabs taken owing to weak condition.
 - 19. iii. 38. Ramstead's operation.
 - 24. iii. 38. Suppuration of operation wound. Pus from wound: type 25 streptococcus.
 - 28. iii. 38. Post-mortem findings: abscess of abdominal wall, acute purulent peritonitis, from which type 25 streptococcus was isolated.
- iii. Female, 5 years: admitted for malnutrition.
 - 23. iii. 38. Admission swabs negative.
 - 11. iv. 38–13. iv. 38. Pyrexia (T. 99; P. 130).
 - 11. iv. 38. Throat swab: type 25 streptococcus.
- iv. Male, 9 years: admitted for rheumatism.
 - 7. iii. 38. Admission swabs negative.
 - 25. iii. 38. Throat swab: type 25 streptococcus.
 Latent infection.
- v. Male, 6 years: admitted for syphilis.
 - 15. iii. 38. Admission swabs negative.
 - 9. v. 38. Throat swab: type 25 streptococcus.
 - 20. vi. 38. Nose swab: type 25 streptococcus.
 Latent infection.
- vi. Male, 9 months: admitted for marasmus.
 - 22. iii. 38. Admission swabs negative.
 - 16. v. 38. Throat swab: type 25 streptococcus.
 - 22. v. 38. Double otitis media. Right and left ear swabs: type 25 streptococcus.
 - 25. v. 38. Rhinorrhoea. Nose swab: type 25 streptococcus.
 - 8. vi. 38. Wound of right mastoidectomy: type 25 streptococcus.
- vii. Female, 10 years: admitted for osteomyelitis.
 - 30. iii. 38. Admission swabs negative.
 - 17. v. 38–21. v. 38. Sore throat.
 - 20. v. 38. Throat swab: type 25 streptococcus.
- viii. Female, 8 years: admitted for appendicitis.
 - 23. iv. 38. Admission swabs negative.
 - 16. v. 38. Throat swab: type 25 streptococcus.
 Latent infection.
- ix. Male, 10 years: admitted for appendicitis.
 - 4. v. 38. Admission swabs negative.
 - 18. v. 38–21. v. 38. Sore throat.
 - 20. v. 38. Throat swab: type 25 streptococcus.
- x. Female, 3 years: admitted for osteochondroma.
 - 8. iv. 38. Admission swabs negative.
 - 23. v. 38. Throat swab: type 25 streptococcus.
 Latent infection.

- xi. Male, 4 years: admitted for appendicitis.
 6. v. 38. Admission swabs negative.
 16. v. 38. Appendicectomy.
 23. v. 38. Throat swab: type 25 streptococcus.
 27. v. 38. Pus from operation wound: type 25 streptococcus.
 28. v. 38. Rhinorrhoea. Nose swab: type 25 streptococcus.
- xii. Male, 4 years: admitted for cyanosis.
 11. v. 38. Admission swabs negative.
 18. v. 38.–23. v. 38. Pyrexia (T. 101.8; P. 115).
 23. v. 38. Throat swab: type 25 streptococcus.
- xiii. Male, 4 years: admitted for tuberculous adenitis.
 13. v. 38. Admission swabs negative.
 23. v. 38. Throat swab: type 25 streptococcus.
 25. v. 38. Suppuration of operation wound (T. 102; P. 120), lasting four weeks
 Pus from wound: type 25 streptococcus.
- xiv. Male, 4 years: admitted for cancrum oris.
 19. v. 38. Admission swabs negative.
 23. v. 38. Swab from cancrum oris: negative.
 30. v. 38. Swab from cancrum oris: type 25 streptococcus.
 Apparently latent infection.
- xv. Male, 10 years: admitted for pneumonia.
 18. v. 38. Admission swabs negative.
 20. vi. 38. Throat swab: type 25 streptococcus.
 Latent infection.
- xvi. Female, 4 years: admitted for hernia.
 3. vi. 38. Admission swabs negative.
 20. vi. 38. Throat swab: type 25 streptococcus.
 Latent infection.
- xvii. Male, 11 years: admitted for tuberculous adenitis.
 9. vi. 38. Admission swabs negative.
 13. vi. 38. Glands excised.
 20. vi. 38. Inflammation of operation wound. Wound and throat swabs: type 25 streptococcus.
- xviii. Male, 2 years: admitted for tonsilitis.
 11. vi. 38. Admission swabs negative.
 20. vi. 38. Tonsillectomy.
 23. vi. 38–24. vi. 38. Pyrexia (T. 99.4; P. 128).
 27. vi. 38. Throat swab: type 25 streptococcus.
- xix. Female, 8 years: admitted for lymphangioma of lip.
 17. vi. 38. Admission swabs negative.
 21. vi. 38. Excision of lymphangioma.
 30. vi. 38. Inflammation of operation wound. Wound swab: type 25 streptococcus.
 1. vii. 38. Swelling of face and pyrexia (T. 103; P. 140).
 11. vii. 38. Abscess of face aspirated. Pus yielded type 25 streptococcus.
- xx. Male, 8 years: admitted for Banti's disease.
 6. vi. 38. Admission swabs negative.
 3. vii. 38. Pyrexia (T. 99.2; P. 100).
 4. vii. 38. Throat swab: type 25 streptococcus.

xxi. Nurse G.

8. iv. 38. Commenced duty on ward. Throat swabs negative until 20. vi. 38, when type 25 streptococcus isolated, as also 4. vii. 38.

11. vii. 38. Ceased duty on ward.

Latent infection.

This outbreak lasted 6½ months and affected twenty children and one nurse. After spreading for 4 weeks in Section I, the infection reached Sections II and III at about the same time and spread in these sections also, while continuing to spread in Section I. The order of cot-spread in the sections was as follows, a second admission to a cot being indicated by the letter *a*.

Section I. Cots 7, 6, 8, 9, 10, 12, 8*a*, 9*a*.

Section II. Cots 18, 20, 19, 16, 18*a*, 24, 19*a*.

Section III. Cots 28, 26, 25, 29, 27.

The mode of transfer of the infection from Section I to Sections II and III is not evident; since the separation of these is by glass screens 7 ft. only in height, the possibility of aerial transmission cannot be excluded, but the transference may have occurred by hands, by fomites or by convalescent children. Apparently the nurses were not carriers, since type 25 haemolytic streptococci were isolated from the throat of one nurse only and then after the outbreak had lasted 4 months.

II. *Type 22 haemolytic streptococcus. Ward A. February to March 1938*

i. Male, 3 years: admitted for hernia.

9. ii. 38. Admission swabs negative.

20. ii. 38. Throat swab: type 22 streptococcus.

21. ii. 38. Sore throat and pyrexia (T. 101·2; P. 120).

23. ii. 38. Left otitis media. Ear swab negative.

24. ii. 38. Left cervical adenitis.

ii. Female, 11 years: admitted for fractured humerus.

24. ii. 38. Admission swabs negative.

28. ii. 38. Throat swab: type 22 streptococcus.

1. iii. 38. Malaise and pyrexia (T. 102; P. 130).

iii. Male, 9 years: admitted for osteomyelitis.

22. xii. 37. Admission swabs negative.

7. iii. 38. Throat swab: type 22 streptococcus.

Latent infection.

iv. Nurse G.

22. i. 38. Commenced duty on ward. Throat swabs negative until 28. ii. 38, when type 22 streptococcus isolated, then negative again until 30. v. 38, when she left ward.

The source of the infection in this outbreak was not determined. The first child, i, to be infected was in cot 29. At the next weekly swabbing another child, ii, in cot 26, and Nurse G. were positive. The following week child iii in cot 27 was also positive. The limitation to one section suggests some form of cot-to-cot spread rather than conveyance by the throat of Nurse G.

III. *Type 11 haemolytic streptococcus. Ward A. February to March 1938*

i. Male, 6 years: admitted for appendicitis.

4. ii. 38. Admission swabs negative.

19. ii. 38–20. ii. 38. Pyrexia (T. 100·4; P. 124).

19. ii. 38. Throat swab: type 11 streptococcus.

- ii. Male, 3 years: admitted for fractured femur.
 - 3. ii. 38. Admission swabs negative.
 - 7. iii. 38. Throat swab: type 11 streptococcus.
 Latent infection.
- iii. Nurse J.
 - 6. i. 38. Commenced duty on ward. Throat swabs negative until 7. iii. 38, when type 11 streptococcus isolated.
 - 1. iv. 38. Ceased duty on ward.
 Latent infection.

The source of the infection in this outbreak was not determined. The first patient from whom type 11 streptococcus was isolated was child i in cot 17. A fortnight later another patient, ii, in cot 21, and Nurse J. were also positive. The proximity of the cots and the limitation of the infection to one section suggest that the spread was of a cot-to-cot type rather than by Nurse J., who was nursing in the other sections also.

IV. *Type 28 haemolytic streptococcus. Ward A. September 1937 to January 1938*

- i. Female, 5 years: admitted for fracture of skull.
 - 19. ix. 37. Admission swabs: type 28 streptococcus.
- ii. Female, 8 years: admitted for crushed toe.
 - 1. x. 37. Admission swabs negative.
 - 4. x. 37. Throat swab: type 28 streptococcus.
- iii. Female, 2 years: admitted for cervical adenitis.
 - 10. x. 37. Admission swabs negative.
 - 18. x. 37. Throat swab: type 28 streptococcus.
 - 25. x. 37. Abscess of neck opened. Swab of pus negative.
 - 13. xi. 37. Pus from abscess of neck: type 28 streptococcus.
- iv. Male, 3 years: admitted for extroversion of bladder.
 - 4. xi. 37. Admission swabs negative.
 - 25. xi. 37–9. xii. 37. Sore throat and pyrexia (T. 101; P. 110).
 - 27. xi. 37. Throat swab: type 28 streptococcus.

The infection may have been introduced by child i in cot 22, whose admission swab yielded type 28 streptococci, or by child ii in cot 30, whose swab on the third day of hospitalization yielded the same organism. If child i were the source of the infection, then apparently the streptococci spread from Section II to Section III. The next patients affected were iii in cot 31 and iv in cot 27, both in Section III, i.e. three of the four patients involved in this outbreak were in the same section. No nurse was found to be a carrier of type 28 streptococci during this time, suggesting that here again the spread may have been direct from cot to cot.

V. *Type 12 haemolytic streptococcus. Ward A. November to December 1937*

- i. Female, 2 years: admitted for cervical adenitis.
 - 19. x. 37. Admission swabs negative.
 - 22. xi. 37. Throat swab: type 12 streptococcus.
 - 24. xi. 37. Pyrexia (T. 100; P. 104).
- ii. Male, 3 years: admitted for cleft palate.
 - 25. ix. 37. Admission swabs negative.
 - 3. xii. 37–11. xii. 37. Sore throat and pyrexia (T. 103; P. 176).
 - 6. xii. 37. Throat swab: type 12 streptococcus.

Child i was in cot 22 and child ii in cot 21, suggesting that the spread of the infection was from patient to patient directly.

VI. *Type 20 haemolytic streptococcus. Ward A. October 1937*

- i. Female, 7 years: admitted for rheumatism.
 - 21. ix. 37. Admission swabs negative.
 - 11. x. 37. Throat swab: type 20 streptococcus.
 - 14. x. 37–15. x. 37. Pyrexia (T. 100·2; P. 132).
- ii. Female, 5 years: admitted for renal colic.
 - 23. ix. 37. Admission swabs negative.
 - 18. x. 37. Throat swab: type 20 streptococcus.
 Latent infection.

Child i was in cot 8 and child ii in cot 9, suggesting again a direct spread from patient to patient.

VII. *Type 9 haemolytic streptococcus. Ward A. February 1938*

- i. Male, 2 years: admitted for cleft palate.
 - 3. i. 38. Admission swabs negative.
 - 16. ii. 38. Operation for repair of cleft palate.
 - 28. ii. 38. Wound swab: type 9 streptococcus. Uvula and $\frac{1}{2}$ cm. of the soft palate healed, but rest of the wound broke down.

The source of the infection in this case was not ascertained.

VIII. *Type 4 haemolytic streptococcus. Ward A. July 1938*

- i. Male, 3 years: admitted for recurrent abscess of perineum.
 - 14. vii. 38. Admission swabs negative.
 - 18. vii. 38. Swab from abscess of perineum negative.
 - 28. vii. 38. Excision of perineal mass.
 - 2. viii. 38. Wound swab: type 4 streptococcus.

The throat swabs of this patient remained negative throughout his stay in hospital. The source of the infection of the perineal operation wound was not ascertained.

IX. *Type 6 haemolytic streptococcal infection. Ward B. Section II. September 1937 to January 1938*

- i. Female, 6 years: admitted for epilepsy.
 - 12. vii. 37. Admission swabs negative.
 - 20. ix. 37. Throat swab: type 6 streptococcus; i.e. positive at outset of investigation. No history of manifest infection.
- ii. Female, 5 years: admitted for rheumatism.
 - 31. vii. 37. Admission swabs negative.
 - 20. ix. 37. Throat swab: type 6 streptococcus: i.e. positive at outset of investigation. History of sore throat on admission.
- iii. Male, 6 years: admitted for bronchitis.
 - 13. x. 37. Admission swabs negative.
 - 18. x. 37. Throat swab: type 6 streptococcus.
 Latent infection.
- iv. Female, 10 years: admitted for rheumatism.
 - 10. x. 37. Admission swabs negative.
 - 2. xi. 37. Throat swab: type 6 streptococcus.
 Latent infection.

- v. Male, 6 years: admitted for tuberculous adenitis.
 - 27. x. 37. Admission swabs negative.
 - 8. xi. 37. Tonsillectomy.
 - 9. xi. 37. Sore throat.
 - 11. xi. 37. Throat swab: type 6 streptococcus.
 - 14. xi. 37. Double otitis media. Right and left ear swabs: type 6 streptococcus.
- vi. Female, 9 years: admitted for chronic appendicitis.
 - 18. xi. 37. Admission swabs negative.
 - 23. xi. 37. Throat swab: type 6 streptococcus.
 - 24. xi. 37. Sore throat (T. 101; P. 140).
- vii. Male, 8 years: admitted for pneumonia.
 - 22. xi. 37. Admission swabs negative.
 - 29. xi. 37-1. xii. 37. Pyrexia (T. 100-2; P. 120).
 - 29. xi. 37. Throat swab: type 6 streptococcus.
- viii. Male, 4 years: admitted for asthma.
 - 29. xi. 37. Admission swabs negative.
 - 13. xii. 37. Throat swab: type 6 streptococcus.
 Latent infection.
- ix. Nurse R.
 - 20. ix. 37. On duty at outset of investigation. Throat swab: type 6 streptococcus. Intermittently positive till 13. xii. 37, when she left ward. No history of manifest infection.
- x. Nurse H.
 - 15. xi. 37. Commenced duty on ward. Throat swab negative.
 - 29. xi. 37. Throat swab: type 6 streptococcus. Intermittently positive till 17. i. 38.
 - 30. xi. 37-5. xii. 37. Sore throat.
 - 28. ii. 38. Ceased duty on ward.

The original source of the infection with type 6 haemolytic streptococci in this outbreak could not be ascertained, as two children and one nurse were already carriers of this type at the outset of the investigation in September 1937. Although Nurses R. and H. worked on both sections of the ward, the outbreak was limited to Section II, suggesting that the nurses were not the manual or oral vectors, but that there was some more direct form of spread from patient to patient. Transfer of infection by doctors or students would also appear to be excluded by this limitation of the outbreak, as is transfer by china, silverware, etc., since the two wards use these from a common supply. There is the possibility of spread among the patients of Section II by playthings, dust, droplets or "droplet nuclei"—a term introduced by Wells & Wells (1936) to indicate the infective particles, which float in the air like smoke, after the evaporation of the moist matter of droplets.

*X. Type 4 haemolytic streptococcus. Ward B. Sections I and II.
December 1937 to June 1938*

- i. Male, 7 years: admitted for nephritis.
 - 29. xii. 37. Admission swabs negative.
 - 7. iii. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- ii. Female, 3 years: admitted for arthritis.
 - 5. i. 38. Admission swabs negative.
 - 7. iii. 38. Pyrexia (T. 100; P. 112).
 - 7. iii. 38. Throat swab: type 4 streptococcus.

- iii. Male, 2 years: admitted for neurofibroma.
 - 31. i. 38. Admission swabs negative.
 - 7. iii. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- iv. Male, 10 years: admitted for chorea.
 - 26. i. 38. Admission swabs negative.
 - 14. iii. 38. Throat swabs: type 4 streptococcus.
 Latent infection.
- v. Male, 2 years: admitted for rickets.
 - 31. i. 38. Admission swabs negative.
 - 21. iii. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- vi. Female, 5 years: admitted for asthma.
 - 7. iii. 38. Admission swabs negative.
 - 11. iv. 38–12. iv. 38. Pyrexia (T. 99.6; P. 110).
 - 11. iv. 38. Throat swab: type 4 streptococcus.
- vii. Female, 5 years: admitted for pyelitis.
 - 23. iii. 38. Admission swabs negative.
 - 11. iv. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- viii. Male, 13 years: admitted for asthma.
 - 4. iv. 38. Admission swabs negative.
 - 11. iv. 38–13. iv. 38. Pyrexia (T. 103; P. 120).
 - 11. iv. 38. Throat swab: type 4 streptococcus.
- ix. Male, 11 years: admitted for chorea.
 - 25. ii. 38. Admission swabs negative.
 - 19. iv. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- x. Female, 13 years: admitted for chorea.
 - 23. iii. 38. Admission swabs negative.
 - 19. iv. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- xi. Male, 3 years: admitted for jaundice.
 - 21. iii. 38. Admission swabs negative.
 - 25. iv. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- xii. Male, 3 years: admitted for indigestion.
 - 12. iv. 38. Admission swabs negative.
 - 9. v. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- xiii. Male, 6 years: admitted for bronchiectasis.
 - 17. v. 38. Admission swabs negative.
 - 25. v. 38. Throat swab: type 4 streptococcus.
 Latent infection.
- xiv. Nurse H.
 - 29. xii. 37. Commenced duty on ward.
 - 7. v. 38. Throat swab: type 4 streptococcus.
 - 14. iii. 38. Ceased duty on ward.
 Latent infection.

This outbreak showed several points of interest. The infection was of a mild type; of thirteen children affected, three only showed any clinical manifestations and these only a mild pyrexia of 1-3 days' duration.

The mode of entry of the infection to the ward was not ascertained, since at one weekly swabbing three children and one nurse were found to be carriers of type 4 haemolytic streptococci. Two of these three children were in Section II and one in Section I. Nurse H. left the ward within a fortnight of her first positive swab, but the type 4 haemolytic streptococcus continued to spread among the patients in both sections for a further period of 10 weeks. No other carriers of type 4 were discovered among the nurses during this period. It was not possible to trace the path of the organism, since at the onset of each fresh infection there was more than one possible source from which it might have been derived.

XI. *Type 3 haemolytic streptococcus. Ward B. Sections I and II.*
December 1937 to February 1938

- i. Female, 1 year: admitted for marasmus.
 15. xi. 37. Admission swabs negative.
 20. xii. 37. Throat swab: type 3 streptococcus.
Latent infection.
- ii. Female, 7 years: admitted for rheumatism.
 26. xi. 37. Admission swabs negative.
 20. xii. 37. Throat swab: type 3 streptococcus.
Latent infection.
- iii. Male, 5 years: admitted for tuberculous adenitis.
 27. x. 37. Admission swabs negative.
 5. i. 38. Throat swab: type 3 streptococcus.
Latent infection.
- iv. Male, 6 years: admitted for nephritis.
 20. xii. 37. Admission swabs negative.
 17. i. 38. Throat swab: type 3 streptococcus.
Latent infection.
- v. Male, 3 years: admitted for dwarfism.
 18. xi. 37. Admission swabs negative.
 22. ii. 38. Throat swab: type 3 streptococcus.
Latent infection.
- vi. Wardmaid M.
 25. x. 37. Commenced duty on ward. Throat swabs negative until 20. xii. 37, when type 3 streptococci present; subsequently negative till close of investigation.
- vii. Nurse I.
 20. xii. 37. Commenced duty on ward. Throat swab negative.
 29. xii. 37-4. ii. 38. Membranous pharyngitis and subsequent debility.
 31. xii. 37. Throat swab: type 3 streptococcus.

Type 3 haemolytic streptococci were isolated at one weekly swabbing from two patients, i and ii, both in Section I, and from one wardmaid, all of whom had negative swabs during the previous 4 weeks. The following week Nurse I. went off duty with membranous pharyngitis, from which type 3 haemolytic streptococci were isolated.

At the next swabbing type 3 streptococci were isolated from the throat swab of a patient, iii, in cot 2, Section II, and 2 weeks later from that of a patient, iv, in the next cot, cot 1, Section II. After the return of Nurse I. to duty (after her 38 days' absence she was still a carrier of type 3 haemolytic streptococci) another child, v, developed the same type, though

the other children had in the meantime either become negative or been discharged. It is possible that Nurse I. may have played some part in the dissemination of the organism in this outbreak.

XII. *Type 28 haemolytic streptococcus. Ward B. Section I.*
March to May 1938

- i. Male, 3 years: admitted for cervical adenitis.
 21. iii. 38. Admission swabs negative.
 28. iii. 38. Throat swab: type 28 streptococcus.
 29. iii. 38. Abscess of neck opened. Swab of pus: type 28 streptococcus.
- ii. Female, 4 years: admitted for bronchiectasis.
 22. iv. 38. Admission swabs negative.
 8. v. 38. Throat swab: type 28 streptococcus.
 Latent infection.
- iii. Male, 5 years: admitted with coeliac disease.
 28. iii. 38. Admission swabs negative.
 16. v. 38. Throat swab: type 28 streptococcus.
 Latent infection.
- iv. Nurse C.
 28. ii. 38. Commenced duty on ward. Throat swab negative.
 4. iv. 38. Throat swab: type 28 streptococcus.
 24. iv. 38. Ceased duty on ward.
 Latent infection.
- v. Nurse D.
 14. iv. 38. Commenced duty on ward. Throat swab negative.
 25. iv. 38. Throat swab: type 28 streptococcus.
 3. vii. 38. Ceased duty on ward.
 Latent infection.

The source of the infection in this outbreak appeared to be a patient, i, who was suffering from cervical adenitis on admission. The pus from the abscess of his neck yielded type 28 haemolytic streptococci. One week later this organism was isolated from the throat swab of Nurse C., and 3 weeks later again from that of Nurse D. From the throat swabs of two more patients in Section II the same organism was also isolated.

XIII. *Type 6 haemolytic streptococcus. Ward B. Section II.*
March to August 1938

- i. Female, 12 years: admitted for bronchitis.
 29. iii. 38. Admission swabs negative.
 2. iv. 38. Quinsy developed.
 4. iv. 38. Throat swab: type 6 streptococcus.
- ii. Female, 11 years: admitted for bronchiectasis.
 24. iii. 38. Admission swabs negative.
 11. iv. 38. Throat swab: type 6 streptococcus.
 12. iv. 38-15. iv. 38. Pyrexia (T. 99.8; P. 120).
- iii. Male, 8 years: admitted for periosteal nodes.
 25. iv. 38. Admission swabs negative.
 30. v. 38. Throat swab: type 6 streptococcus.

- iv. Male, 6 years: admitted for bronchiectasis.
 - 17. v. 38. Admission swabs negative.
 - 28. v. 38-2. vi. 38. Pyrexia (T. 101.2; P. 130).
 - 28. v. 38. Throat swab: type 6 streptococcus.
- v. Male, 6 years: admitted for nephritis.
 - 4. v. 38. Admission swabs negative.
 - 20. vi. 38. Throat swab: type 6 streptococcus.
 Latent infection.
- vi. Nurse P.
 - 15. vii. 38. Commenced duty on ward. Throat swabs negative until I. viii. 38, when type 6 streptococcus isolated; then negative till close of investigation.

All the six patients involved in this outbreak were in the same section, Section II, and all developed infection with type 6 haemolytic streptococci before Nurse P. also became positive. This distribution suggests that a direct form of spread occurred from patient to patient, rather than that the infection was disseminated by the hands or throats of the staff.

XIV. *Type 20 haemolytic streptococcus. Ward B. Sections I and II.*
April 1938

- i. Female, 8 years: admitted for bronchitis.
 - 28. ii. 38. Admission swabs negative.
 - 11. iv. 38. Throat swab: type 20 streptococcus.
 Latent infection.
- ii. Male, 4 years: admitted for congenital heart disease.
 - 28. iii. 38. Admission swabs negative.
 - 25. iv. 38. Throat swab: type 20 streptococcus.
 Latent infection.
- iii. Male, 3 years: admitted for indigestion.
 - 12. iv. 38. Admission swabs negative.
 - 25. iv. 38. Throat swab: type 20 streptococcus.
 Latent infection.

Three children were affected in this outbreak, the first in cot 6, Section II and the others in cots 9 and 10, Section I. The mode of entry of the infection and the method of spread were not determined. None of the nurses were carriers of type 20 haemolytic streptococci during this period.

XV. *Type 28 haemolytic streptococcus. Ward B. Sections I and II.*
December 1937

- i. Male, 4 months: admitted for eczema.
 - 17. xi. 37. Admission swab negative.
 - 6. xii. 37. Throat swab: type 28 streptococcus.
 - 7. xii. 37-9. xii. 37. Membranous pharyngitis and pyrexia (T. 101; P. 160).
- ii. Male, 4 years: admitted for fibrosis of lung.
 - 30. xi. 37. Admission swabs negative.
 - 6. xii. 37. Throat swab: type 28 streptococcus.
 Latent infection.

The connexion, if any, between the infections in these two patients, i in cot 1, Section I, and ii in cot 2, Section II, could not be traced.

Diphtheria

No systematic bacteriological investigation was made into the outbreaks of diphtheria in the wards. The data here recorded were collected from the routine laboratory material and from information obtained from the fever hospitals to which the children were transferred. Throat and nose swabs were taken from the patients and nurses in the wards following the first case of diphtheria, and the swabs examined for the presence of *C. diphtheriae*.

I. *Diphtheria outbreak. Ward A. November to December 1937*

- i. Female, 7 years: admitted for poliomyelitis.
8. xi. 37. Faucial diphtheria.
Throat swab: *C. diphtheriae* isolated.
- ii. Male, 1 year: admitted for urethritis.
10. xi. 37. Nasal swab: *C. diphtheriae* isolated.
- iii. Male, 2 years: admitted for haemangioma.
10. xi. 37. Nasal swab: *C. diphtheriae* isolated.
- iv. Female, 6 years: admitted for adenitis.
10. xi. 37. Throat and nasal swabs: *C. diphtheriae* (virulent) isolated.
Fever hospital report: nasal diphtheria.
- v. Male, 4½ years: admitted for hypospadias.
10. xi. 37. Throat swab: *C. diphtheriae* isolated.
- vi. Female, 2 years: admitted for adenitis.
16. xi. 37. Nasal swab: *C. diphtheriae* isolated.
- vii. Male, 9 years: admitted for fractured femur.
24. xi. 37. Faucial diphtheria.
Throat swab: *C. diphtheriae* (virulent) isolated.
- viii. Male, 4 years: admitted for arthritis.
28. xi. 37. Faucial diphtheria.
- ix. Female, 2 years: admitted for adenitis.
30. xi. 37. Throat and nasal swab: *C. diphtheriae* (virulent) isolated.
Fever hospital report: anterior-nasal diphtheria.
- x. Male, 10 years: admitted for cellulitis.
30. xi. 37. Throat swab: *C. diphtheriae* isolated.
Fever hospital report: diphtheria carrier.
- xi. Female, 3½ years: admitted for appendicitis.
3. xii. 37. Throat swab: *C. diphtheriae* isolated.
Fever hospital report: diphtheria carrier, discharged after 9½ months.

Altogether, therefore, *C. diphtheriae* was isolated from eleven patients, all of whom had had negative throat and nasal swabs on admission to the ward. Five showed clinical manifestations of infection and six were apparently carriers only. The first patient to contract diphtheria had been in the ward 9 weeks and was in Section I. Two other children in this section, six in Section II and two in Section III, were affected. The source of the infection was not detected and no *C. diphtheriae* were isolated from the throats or noses of the nursing staff. The children with *C. diphtheriae* were removed to fever hospitals and the ward was closed for a few weeks.

II. *Diphtheria outbreak, Ward B. Section II. March 1938*

- i. Male, 10 years: admitted for pyelitis.
7. iii. 38. Throat swab: *C. diphtheriae* isolated.
- ii. Male, 11 years: admitted for chorea.
9. iii. 38. Throat swab: *C. diphtheriae* isolated.
- iii. Male, 7 years: admitted for nephritis.
11. iii. 38. Throat swab: *C. diphtheriae* isolated.
- iv. Male, 6 years: admitted for nephritis.
14. iii. 38. Nasal swab: *C. diphtheriae* isolated.
Fever hospital report: transient carrier.

The source of the infection was not determined and no *C. diphtheriae* were isolated from the noses or throats of the nursing staff. The children affected were sent to fever hospitals.

Dysentery

No systematic bacteriological investigation was made into the two outbreaks of dysentery which occurred in Wards A and B. Such data as are recorded here were gathered from the routine laboratory material and from the clinical notes.

I. *Dysentery, Ward B. Section II. December 1937*

- i. Nurse B., 22 years.
3. xii. 37. Vomiting, diarrhoea, pyrexia; appendicectomy, appendix found normal.
10. xii. 37. Stool: *Bact. sonnei* isolated.
- ii. 6 years: admitted for asthma.
7. xii. 37-11. xii. 37. Diarrhoea with mucus and blood. No bacteriological investigation made.
- iii. 6 years: admitted for pneumonia.
10. xii. 37-14. xii. 37. Diarrhoea and pyrexia (T. 101-2).
No bacteriological investigation made.
- iv. 6 years: admitted for tuberculous adenitis.
16. xii. 37-24. xii. 37. Diarrhoea with blood and mucus.
18. xii. 37. Stool: numerous *Bact. sonnei* isolated.
- v. 4 years: admitted for medulloblastoma.
20. xii. 37-22. xii. 37. Diarrhoea and pyrexia (T. 100).
21. xii. 37. Stool: *Bact. sonnei* isolated.
- vi. 6 years: admitted for pneumonia.
22. xii. 37-25. xii. 37. Diarrhoea with blood and mucus, pyrexia (T. 104-4).
23. xii. 37. Stool: *Bact. sonnei* isolated.
- vii. 6 years: admitted for nephritis.
22. xii. 37-25. xii. 37. Diarrhoea and pyrexia (T. 100).
No bacteriological investigation made.
- viii. 4 years: admitted for fibrosis of lung.
27. xii. 37. Diarrhoea with mucus, pyrexia (T. 101).
No bacteriological investigation made.

The stools of only four of the eight persons affected were examined bacteriologically, and these all yielded *Bact. sonnei*. From the similarity of all the attacks, it seems probable that the infecting organism in the remaining four was also *Bact. sonnei*. The outbreak was characterized by a swift spread, lasting altogether from 3. xii. 37 to 31. xii. 37. It was limited to Section II, although the same nurses were working in Section I.

II. *Dysentery. Ward A. February to March 1938*

- i. Male, 4 years: admitted for dysentery.
25. ii. 38. Stool on admission: numerous *Bact. sonnei* isolated.
- ii. Male, 3 years: admitted for pneumonia.
3. iii. 38–9. iii. 38. Diarrhoea.
3. iii. 38. Stool: numerous *Bact. sonnei* isolated.
- iii. Male, 6 years: admitted for undescended testicle.
8. iii. 38–11. iii. 38. Diarrhoea with blood and mucus.
9. iii. 38. Stool: numerous *Bact. sonnei* isolated.

After the admission of one patient, i, with dysentery to cubicle 15, two further cases occurred, one in cubicle 1 and the other in cubicle 16. *Bact. sonnei* was isolated from the stools of all three children. Apparently, therefore, the infection in this instance had spread out of and into the isolation cubicles, but not to the patients in the open ward.

Gastro-enteritis of infancy. Ward A

The data here recorded refer to six infants who developed intercurrent gastro-enteritis during their stay in Ward A. The material has been collected from the clinical notes and no special bacteriological investigation was made.

- i. Female, 3 months: admitted for talipes equino-varus.
19. iv. 38. Developed diarrhoea and vomiting. Gradual recovery.
- ii. Male, 7 months: admitted for malnutrition.
19. iv. 38. Developed diarrhoea and vomiting lasting till 5. v. 38. Gradual recovery.
- iii. Female, 4 months: admitted for fractured ribs.
6. vi. 38. Developed diarrhoea and vomiting. Gradual recovery.
- iv. Female, 8 months: admitted for wasting.
11. vi. 38. Developed diarrhoea and vomiting; subsequently measles, broncho-pneumonia and death.
- v. Male, 4 months: admitted for pyloric stenosis.
25. vii. 38. Developed diarrhoea and vomiting.
13. viii. 38. Died.
- vi. Female, 4 months: admitted for abscess of leg.
29. viii. 38. Developed diarrhoea and vomiting. Gradual recovery.

Epidemic catarrhal jaundice. Ward B. June to August 1938

An outbreak of epidemic catarrhal jaundice occurred in Ward B during the summer of 1938. It affected three nurses and one child as follows:

- i. Nurse C., 22 years. Onset 20. vi. 38.
- ii. Patient, 3 years: admitted for rheumatoid arthritis. Onset 29. vi. 38.
- iii. Nurse M., 20 years. Onset 27. vii. 38.
- iv. Nurse P., 22 years. Onset 1. viii. 38.

In all these cases the onset was acute with pyrexia reaching 104·8°, 105°, 103·4° and 103·2° respectively. Jaundice was observed 2–5 days later and subsided gradually. (It is interesting to note that the condition of rheumatoid arthritis of child ii was markedly improved by the attack.) The origin of the outbreak was not detected, and the long period of contact of the nurses with the patient precluded the possibility of estimating the incubation period.

Acute otitis media

Seventeen patients were found on admission to be suffering from acute otitis media with or without other clinical conditions, and seven patients developed the condition while in hospital. Of these twenty-four children, fifteen were under the age of 1 year. In two only was otitis media the sole reason for admission, the others suffering from acute gastro-enteritis, pneumonia or marasmus. Myringotomy was performed on eighteen, in the remainder the eardrums either perforating spontaneously or the inflammation subsiding. Ear swabs were taken from only eight of these patients. From three of these swabs were grown type 12, type 6 and type 25 haemolytic streptococci respectively; from the other five no haemolytic streptococci were grown, one yielding *Proteus vulgaris*.

DISCUSSION

On clinical grounds alone the varied manifestations of haemolytic streptococcal infection might lead to the supposition that they were unrelated occurrences. It has been possible in this investigation to show a connected chain of infection by one or other type of haemolytic streptococcus. A type 25 haemolytic streptococcal outbreak, for example, lasting 6½ months and involving twenty children and one nurse, produced clinical manifestations of a varied nature, e.g. wound suppuration, sore throat and otitis media. That this was due to cross-infection and not merely to the high incidence of a prevalent type of haemolytic streptococcus is shown from the fact that nineteen of these patients had negative swabs on admission (the admission swab of one was omitted owing to his feeble condition), and fifteen at subsequent weekly swabbings also.

Further, the general incidence of haemolytic streptococcal infection among the children on admission was considerably smaller than during an outbreak; i.e. of the 551 patients only 34 (or 6·1 %) were found to be carriers of typable haemolytic streptococci on admission. The distribution of these types has been recorded above, and it may be noted that no one type was found to occur more than four times in the admission swabs. The presence, therefore, for example, of type 25 haemolytic streptococci in a series of twenty children did not reflect merely its general incidence in the child population at large.

The source of the infection in most of the outbreaks was not ascertainable from the data collected. In general the precautionary measures of isolation by cubicles or screens for the small number of children found on admission to be carriers of haemolytic streptococci were found to be effective in preventing the appearance in other patients of the infecting type of streptococcus. It appears,

therefore, that the infection may have been introduced by persons other than patients, e.g. visitors, students, doctors, or may even have had its origin from dried haemolytic streptococci in dust or previously used playthings or bedding.

The path of spread of infection by haemolytic streptococci was also not clearly ascertained. Two outbreaks of type 6 haemolytic streptococcal infection were of particular interest. They were both entirely limited to Section II of Ward B, although the same nurses were working throughout in Section I, suggesting that the infection spread directly from patient to patient rather than by the nurses' hands or throats. The nurses' throats, in fact, did not appear to play an important part in the dissemination of infection. In outbreak I, for example, the type 25 streptococcus spread amongst the patients for 4 months before being isolated from the throat of any nurse, and in the type 4 outbreak in Ward B the infection spread amongst the patients for 10 weeks after one nurse, a carrier of this type, had ceased duty on the ward.

More precise information about the path of spread of haemolytic streptococci in hospital wards can come only from further work. For this purpose it would be essential to swab the patients and nurses at more frequent intervals than 1 week, and, in order to keep the bacteriological work within practical limits, a smaller ward unit with more strictly controlled admittance and swabbing of personnel and visitors would be desirable. It would be instructive at the same time to study the bacterial content of the air and dust of the ward and the bacteriological efficacy of ward masks and general nursing technique. In this way it should be possible to determine whether any means, short of an individual cell for each cot, will prove effective in combating cross-infection.

The investigation has confirmed the views of McKhann, Steeger & Long (1938) in the United States, who have stressed the important role of respiratory infections in infant hospitals, as compared with that of so-called contagious disease. In the wards of this hospital during the year, one case only of measles occurred in which the patient had been in hospital longer than the incubation period, and none of chicken-pox, whooping-cough or mumps, as compared with seventy-two infections, latent or manifest, with haemolytic streptococci, and fifteen with *C. diphtheriae*.

Brennemann (1932) also emphasized the danger of respiratory disease among infants in hospital wards. He found that at least 50% of infants dying in infant wards from almost any cause, but especially from severe gastrointestinal disorders, have pus in the mastoid antrum at autopsy. In the present investigation it must be admitted that the bacteriological data regarding acute otitis media in infants is inadequate. This has largely been due to the difficulty of obtaining aural swabs prior to the administration of disinfectant eardrops. The whole question of acute otitis media in infants, including its relation to gastro-enteritis, is worth more detailed bacteriological study, using a technique capable of overcoming the special difficulties involved.

SUMMARY AND CONCLUSIONS

1. During a period of 1 year the incidence of infection with haemolytic streptococci was determined among children on admission to, and during residence in, the children's wards of University College Hospital, London.

2. The increased incidence among those in residence, 13.1% of whom acquired haemolytic streptococci during their stay, was due principally to outbreaks of infection by these organisms. By the slide agglutination method the majority of strains could be assigned to one or other of Griffith's thirty types and the presumed path of their spread studied.

3. The source of the infection in most of the outbreaks was not ascertainable from the data collected, but in general it did not appear to be in the patients themselves.

4. With a few exceptions, isolation by cubicles was an effective measure in preventing the spread of haemolytic streptococci.

5. In general the haemolytic streptococci seemed to spread from patient to patient, though the exact mode of spread was not ascertained.

6. The clinical manifestations of infection by any one type of haemolytic streptococcus was varied, e.g. wound suppuration, sore throat, pyrexia, otitis media. Many of the infections were "latent".

7. In addition to the haemolytic streptococcal outbreaks, there were two outbreaks of diphtheria (fifteen patients), two of *Bact. sonnei* dysentery (ten patients and one nurse), one of catarrhal jaundice (one patient and three nurses), six cases of intercurrent gastro-enteritis of infancy and one case of measles.

8. In all, at least 104 (or 18.9%) of the 551 patients of these wards developed intercurrent infections, manifest or latent, during their stay in hospital.

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