

INTER-HOSPITAL CROSS-INFECTION OF EPIDEMIC INFANTILE GASTRO-ENTERITIS ASSOCIATED WITH TYPE STRAINS OF *BACTERIUM COLI*

BY K. B. ROGERS, M.D. (LOND.) AND S. J. KOEGLER, M.D. (CANADA)
From the Children's Hospital, Birmingham

(With 3 Figures in the Text)

CONTENTS

	PAGE
Introduction	152
Explanation of Figs. 1-3	153
First epidemic (β -type <i>Bact. coli</i>) (Fig. 1)	153
Hospital HG	154
Parsons' block, ground floor, Birmingham Children's Hospital	154
Second epidemic (α -type <i>Bact. coli</i>) (Fig. 2)	155
Hospital W	155
Hospital K	156
Out-patient department, Birmingham Children's Hospital	156
Hospital H	156
Third epidemic (α -type <i>Bact. coli</i>) (Fig. 3)	157
Hospital S	157
Parsons' block, ground floor, Birmingham Children's Hospital	157
Hospital D	158
Parsons' block, second floor, Birmingham Children's Hospital	159
Discussion	160
Summary	160

INTRODUCTION

The α - and β -types of *Bacterium coli* have been used in this investigation to demonstrate the possibility of inter-hospital cross-infection.

Two factors have limited this investigation. First, if an outbreak of gastro-enteritis associated with a type strain of *Bact. coli* was to be investigated, it was necessary for that outbreak to occur in a hospital which had been free from this particular strain for several weeks at least. Secondly, if there should be a new admission who was excreting the same type strain of *Bact. coli*, as that which was already being investigated in the ward, no further cases of gastro-enteritis could be attributed to the primary source.

It has been shown by Rogers (1951*a*) that there was no evidence of cross-infection between different floors in the Parsons' block at the Birmingham Children's Hospital. For this reason, in this investigation, a floor is considered to be a unit comparable with other hospitals in which small epidemics were investigated.

EXPLANATION OF FIGS. 1-3

The figures (Figs. 1-3) show only those patients who were excreting the particular type of *Bact. coli* that was being investigated. To simplify the figures no record is made of the chloromycetin therapy that was given to many infants, often as soon as diarrhoea became apparent. In several instances another type strain of *Bact. coli* was isolated from other cases of gastro-enteritis in the ward, but these patients are not recorded unless they later acquired the type strain which was being investigated.

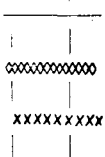
Key to Figs. 1-3 (from above downwards)

Patients in hospital



No diarrhoea or vomiting	No α - or β -type of <i>Bact. coli</i> present
No diarrhoea or vomiting	α - or β -type of <i>Bact. coli</i> present
Diarrhoea and vomiting	α - or β -type of <i>Bact. coli</i> present
No diarrhoea but vomiting	α - or β -type of <i>Bact. coli</i> present
Diarrhoea and vomiting	No α - or β -type of <i>Bact. coli</i> present

Patients passing from one hospital to another



No diarrhoea or vomiting	—
Vomiting but no diarrhoea	—
Diarrhoea and vomiting	—

Vertical lines are drawn at weekly intervals

Cultures were made at the Birmingham Children's Hospital from the first faeces passed after admission, and subsequently on an average twice weekly. If enteritis developed and/or chloromycetin therapy was given, daily cultures were made if possible, even if the diarrhoea had ceased.

Rectal swabs were taken from children attending the out-patient department who had diarrhoea or who had been in the Parsons' block.

Hospitals, other than the Birmingham Children's Hospital, provided swabs from patients and their contacts at irregular intervals.

FIRST EPIDEMIC (β -TYPE *BACT. COLI*) (Fig. 1)

Three hospitals were concerned in this investigation, as well as the out-patient department of one of these hospitals. The epidemic was associated with the β -type of *Bact. coli*.

The patient HQ had developed gastro-enteritis 2 days after discharge from Hospital G and 7 days before the patient DB became ill. Patients TS and JB

developed gastro-enteritis within a few days of the onset of an attack of the same illness in patient DB. The β -type of *Bact. coli* was isolated from all these cases.

Hospital HG

Patient HQ was admitted to a small isolation Hospital HG with mild gastro-enteritis in which for the first 5 days vomiting predominated over diarrhoea. On the fifth day the child was sent to see a consultant in the out-patient department of the Birmingham Children's Hospital and then returned to Hospital HG. The day after this visit the child started a more severe attack of diarrhoea, and cultures showed that the β -type of *Bact. coli* was present in her faeces. Three days later HQ, now gravely ill, was admitted to the ground floor of the Parsons' block.

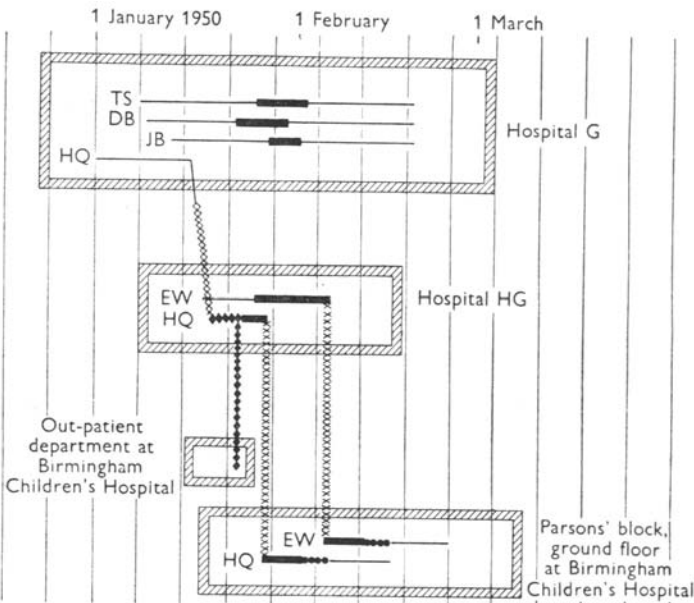


Fig. 1. In order from above downwards:

Hospitals	Patients
Hospital G	TS, DB, JB, HQ
Hospital HG	EW, HQ
Out-patient department, Birmingham Children's Hospital	HQ
Parsons' block, ground floor, Birmingham Children's Hospital	EW, HQ

Parsons' Block Ground Floor, Birmingham Children's Hospital

The patient EW had been admitted to the isolation Hospital HG with pneumonia and developed gastro-enteritis 9 days after admission, the β -type of *Bact. coli* being isolated from the faeces. This child became gravely ill and was admitted to the same ward as the infant HQ. As there were other children harbouring the β -type of *Bact. coli* in this ward, no further infections could be traced to either EW or HQ.

The lessons to be learnt from this epidemic are first, the danger of children with gastro-enteritis attending out-patient departments and infecting other children;

and secondly, the necessity for knowing the history of all children after discharge from hospital.

At Hospital HG there was an erroneous impression of the sequence of events, because the paediatricians there were unaware of either the onset of gastro-enteritis or the journeyings of the child HQ. It was thought that only three cases of gastro-enteritis were connected, and that DB had infected TS and JB after a very short incubation period. Routine swabbing of all the children in the ward housing the original four infants might have disclosed which child caused the outbreak.

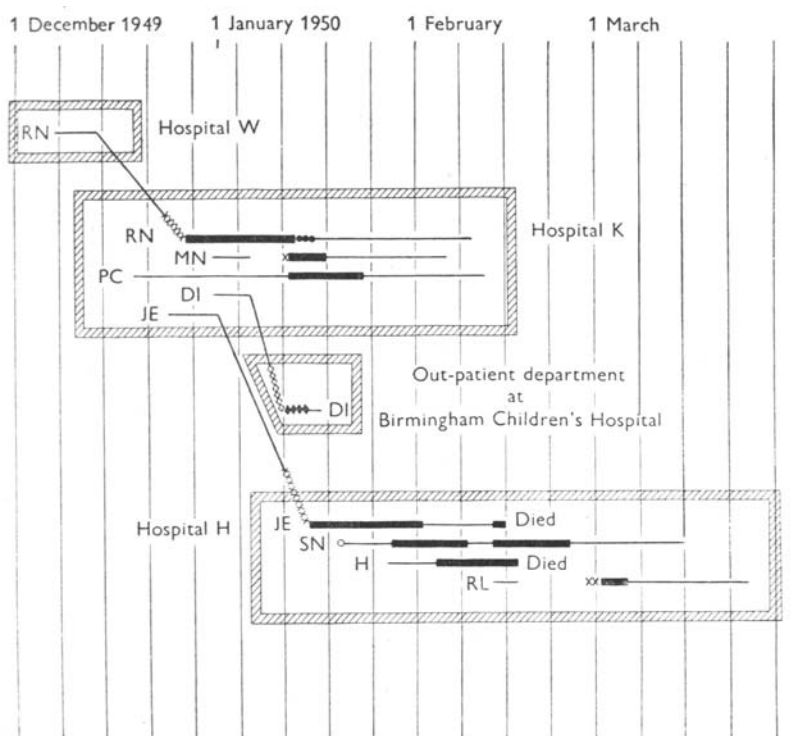


Fig. 2. In order from above downwards:

Hospitals	Patients
Hospital W	RN
Hospital K	RN, MN, PC, DI, JE
Out-patient department, Birmingham Children's Hospital	DI
Hospital H	JE (died), SN, H (died), RL

SECOND EPIDEMIC (α -TYPE *BACT. COLI*) (Fig. 2)

Hospital W

The patients concerned were all infected with the α -type of *Bact. coli*. Four hospitals were involved.

This hospital had had a severe epidemic of infantile gastro-enteritis in the autumn of 1949, when some of the patients had been shown to have the α -type of

Bact. coli in their faeces. Since then occasional swabs from ill children had shown that the α -type was still present in the hospital.

The child RN was in hospital for 7 days with bronchitis. Eleven days after discharge this child developed enteritis and 4 days later was admitted to Hospital K; faecal culture now showed the presence of the α -type of *Bact. coli*.

Hospital K

This hospital had had no cases of gastro-enteritis between November and the day of RN's admission, 28 December.

It will be seen from Fig. 2, that MN was in hospital for 6 days whilst RN still had gastro-enteritis. MN returned with an attack of gastro-enteritis 6 days after discharge, having had diarrhoea of 1 day's duration before re-admission. The α -type of *Bact. coli* was now isolated from MN's faeces. The child PC, who had been in hospital since the previous November, started an attack of gastro-enteritis a day later than the child MN and the α -type of *Bact. coli* was now present in his faeces. The children DI and JE were in hospital for 6 and 8 days respectively before they were discharged. Both developed gastro-enteritis whilst out of hospital, within 2 days of the other children who remained in Hospital K.

Out-patient department, Birmingham Children's Hospital

DI was seen in the out-patient department of the Birmingham Children's Hospital, and was diagnosed as a mild case of gastro-enteritis, though suffering more from vomiting than from diarrhoea. A rectal swab showed the presence of the α -type of *Bact. coli*.

Hospital H

This hospital had been clear of the α -type of *Bact. coli* for more than a month before the child JE was admitted. JE had had diarrhoea for 4 days and was nearly moribund on admission. Cultures of the faeces showed the presence of the α -type of *Bact. coli*. After a very severe illness this child had shown a marked improvement and appeared to be recovering, but 12 days later there was a sudden relapse followed by death.

The child SN was admitted with a gastro-intestinal upset which responded excellently to treatment with intravenous fluids for 1 day. No α -type *Bact. coli* was isolated at that time. Eight days after admission a much more severe attack of gastro-enteritis developed and the α -type of *Bact. coli* was now isolated. The child had another relapse before recovering completely.

The child H was admitted suffering from congenital pyloric stenosis. A Rammstedt's operation was performed, and 9 days after admission severe and fatal gastro-enteritis developed. The α -type of *Bact. coli* was isolated from the faeces.

The child RL was in hospital suffering from a feeding disorder for 4 days. Twelve days after discharge he started an attack of mild gastro-enteritis. He was re-admitted 2 days later and the α -type of *Bact. coli* was isolated.

In this epidemic four hospitals were involved. Four children were discharged to be re-admitted with gastro-enteritis to their original or another hospital. As

in the first epidemic, a child carrying the α -type of *Bact. coli* was seen in the out-patient department of the Birmingham Children's Hospital, where it was a potential danger to other children, since some infants are thought to have been infected in this department (Rogers, 1951*a, b*).

THIRD EPIDEMIC (α -TYPE *BACT. COLI*) (Fig. 3)

The patients involved in this series were infected with the α -type of *Bact. coli*.

Hospital S

Hospital S had had a severe epidemic of infantile gastro-enteritis during the early part of December 1949; the α -type of *Bact. coli* was isolated from all the patients. Nearly all the patients recovered and were discharged; those who remained had their faeces examined to exclude the presence of the α -type of *Bact. coli*.

The child JP was in hospital for 6 days and was re-admitted 3 days later with gastro-enteritis of 1 day's duration. Routine swabbing showed that the child PP had the α -type of *Bact. coli* in his faeces on 1 January 1950, but at that time he was not suffering from the gastro-intestinal upset which started 1 day later.

Fig. 3 indicates when and from whom the α -type of *Bact. coli* was isolated. It also shows that, except for the first two infants, all the babies were admitted to Hospital S suffering from diseases other than gastro-enteritis, gastro-enteritis only developing after their admission.

The child JS was discharged from hospital well, but was re-admitted with gastro-enteritis 2 days later. This child and the child GG both died as a result of gastro-enteritis.

In this hospital the α -type of *Bact. coli* appeared in the faeces of fourteen children over a period of 3 months. Only one of these children, AW, had no symptoms. Another child, M, suffered from vomiting only. All the remaining children had some diarrhoea.

Despite the infrequency of the cultivation of faeces from the children in Hospital S, Fig. 3 shows that several children (PP, DH, SH and AY, LK in relapse) had the α -type of *Bact. coli* present in their faeces before the onset of primary attacks or relapses of gastro-enteritis.

Whilst this epidemic was in progress, two infants were discharged from Hospital S as recovered, yet they caused epidemics of gastro-enteritis in the Parsons' block, ground floor and Parsons' block, second floor and also in Hospital D.

Parsons' block ground floor, Birmingham Children's Hospital

The child SM was in Hospital S for a week and developed gastro-enteritis 5 days after discharge. He was admitted to the first floor of the Parsons' block at the Birmingham Children's Hospital. The morning after SM's admission it was known that the α -type of *Bact. coli* was present in his faeces, and as this ward had been free from the α -type of *Bact. coli* for several months SM was transferred to the ground floor of the Parsons' block. The ground floor, although it had been free from the α -type of *Bact. coli* for 49 days, was admitting cases of gastro-enteritis.

Following SM's brief stay on the first floor, no cases of gastro-enteritis occurred which were associated with the α -type of *Bact. coli*. This is of interest for the child was only in the cubicle for 18 hr. and yet 5 hr. after he left the α -type of *Bact. coli* was recovered from the cubicle furnishings. After SM had been admitted to the ground floor, the child JH developed gastro-enteritis 2 days after the α -type of *Bact. coli* was first isolated from his faeces. GN, who had been in hospital for 4 days, had to be re-admitted with gastro-enteritis which started 10 days after his discharge and 2 days before he was re-admitted. No α -type of *Bact. coli* was isolated from GN when he was first in the ground floor of the Parsons' block, but it was present on his re-admission.

The child VB had the α -type of *Bact. coli* in her faeces for the first time on the day of her discharge from hospital. Whilst out of hospital this child developed a cough and vomited and was admitted to another Hospital D, where she was kept for 4 days. On the fourth day of her stay in hospital she started an attack of enteritis and was transferred back to the ground floor of the Parsons' block.

It will be seen from Fig. 3 that the child AL was admitted to the ground floor of the Parsons' block from the second floor of the Parsons' block suffering from gastro-enteritis associated with strains of the α -type of *Bact. coli* which were direct descendants of those transported from Hospital S. This child AL was transferred because the second floor of the Parsons' block was closed for cleaning, and the middle floor of the block had now been clear of the α -type of *Bact. coli* for more than 9 months.

The ground floor of the Parsons' block had been clear of the α -type strains of *Bact. coli* for 59 days before AL arrived, and following his admission another patient, BA, started to excrete the α -type of *Bact. coli*: 4 days after the first positive culture was obtained BA started a mild attack of gastro-enteritis. The arrow which points to the end of BA's record indicates that on that date another child harbouring the α -type of *Bact. coli* was admitted to the ground floor of the Parsons' block, so that the story comes to an end at this point.

Hospital D

Routine cultures had disclosed that this hospital had been free from the α -type of *Bact. coli* for 121 days. Following the admission of VB the α -type of *Bact. coli* was isolated from four children three of whom developed gastro-enteritis. The fourth infant, RE, suffered from fibro-cystic disease of the pancreas which made it impossible to know if the diarrhoea had increased. GW was a premature baby who developed a very severe gastro-enteritis 12 days after the admission of VB and after surviving two relapses he died in the third relapse. The α -type of *Bact. coli* was isolated during every relapse.

The other two children, TC and RA, developed gastro-enteritis within a day of GW but made good recoveries, although one of them was excreting the α -type of *Bact. coli* for several days after discharge from hospital.

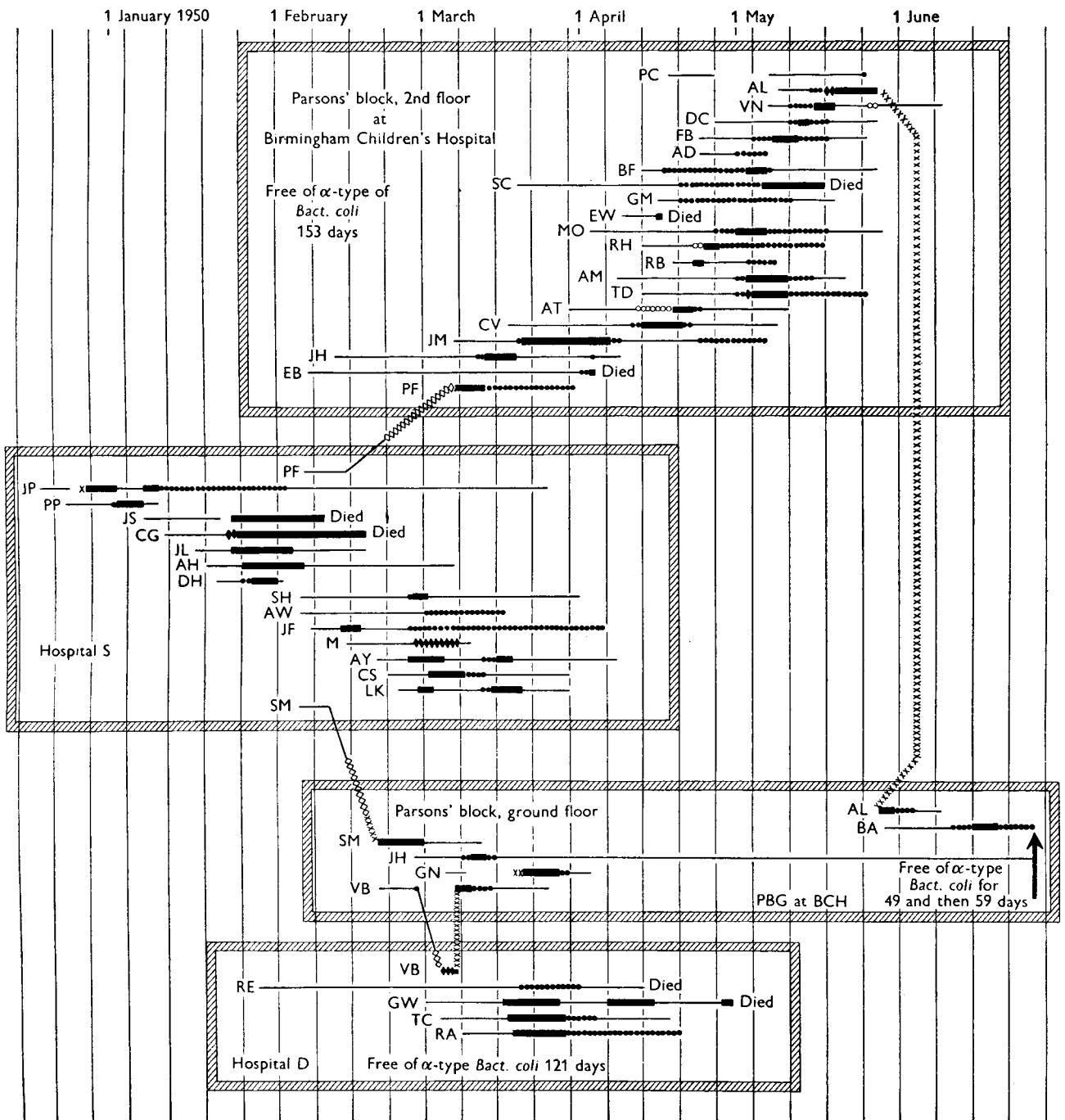


Fig. 3. In order from above downwards:

Hospitals	Free of α -type <i>Bact. coli</i>	Patients
Parsons' block, second floor, Birmingham Children's Hospital	Free of α -type <i>Bact. coli</i> 153 days	PC, AL, VN, DC, FB, AD, BF, SC (died), GM, EW (died), MO, RH, RB, AM, TD, AT, CV, JM, JH, EB (died), PF
Hospital S	—	JP, PP, JS (died), CG (died), JL, AH, DH, SH, AW, JF, M, AY, CS, LK, SM
Parsons' block, ground floor	Free of α -type <i>Bact. coli</i> 49 and then 59 days	AL, BA, SM, JH, GN, VB
Hospital D	Free of α -type <i>Bact. coli</i> 121 days	VB, RE (died), GW (died), TC, RA

Parsons' block, second floor, Birmingham Children's Hospital

This ward had been free of the α -type of *Bact. coli* for 153 days before the child PF was admitted. PF was in Hospital S suffering from otitis media and bronchitis. Eight days after discharge the child started to vomit and cough. The severity of both symptoms increased and on admission he was dehydrated and very cyanosed. The α -type of *Bact. coli* was isolated from a specimen of faeces taken on admission, but it was not until the evening of the day after admission that diarrhoea started. The α -type of *Bact. coli* was present in PF's faeces throughout his stay in the second floor of the Parsons' block. Following the admission of this child twenty children who had previously been free from the α -type of *Bact. coli*, either already patients in the ward or else new admissions to it, started to excrete this organism. The infants GM, AD and PC had no gastro-intestinal symptoms attributable to the presence of the α -type of *Bact. coli*. The α -type of *Bact. coli* did not appear in the faeces of the infant PC until the day of his discharge. During more than a month's follow up in the out-patient department no symptoms of gastro-enteritis developed.

The children EB, EW and SC all died, but their deaths cannot be attributed to the associated gastro-enteritis. EB, who was a case of biliary cirrhosis, was in hospital from 10 February to 4 April 1950, during which time no organisms of the α -type of *Bact. coli* were isolated from her faeces but they were isolated from swabs at post-mortem, when a terminal gastro-enteritis was discovered. It is of interest that on 31 March no organisms of the α -type of *Bact. coli* were isolated from EB's faeces, but on 1 April, in a general investigation of all the feeding teats in use in the Parsons' block, the α -type of *Bact. coli* was grown from the teat used by this child. It is tempting to present this as proof that the teat was the vehicle of entry of the α -type of *Bact. coli*, but it is far more likely that the teat became infected from material regurgitated from the stomach. These α - and β -types of *Bact. coli* could be recovered from the stomachs and from the gastro-intestinal tract, as far as the colon, of all the patients who died with gastro-enteritis associated with these organisms.

EW was a premature baby who died from a *Bact. coli* meningitis. None of the type strains of *Bact. coli* were isolated from the meningeal exudate. There was a terminal enteritis associated with the α -type of *Bact. coli*. SC died from fibrocystic disease of the pancreas. In Fig. 3 SC is shown as developing gastro-enteritis 12 days before death, but although it was reported that the diarrhoea increased before death in this disease it is hard to be certain that such a finding is not natural. It will be seen from Fig. 3 that, except for the cases AT and RH, positive cultures were obtained in every case before the onset of the diarrhoea. The child AL has already been referred to in the notes on the Parsons' block, ground floor.

DISCUSSION

Each of the three epidemics described was associated with one type of *Bact. coli*; in each case the organism was known to have been present in the parent hospital but absent from the receiving hospital for several weeks.

It is felt that a search for these type strains of *Bact. coli* should be made in all paediatric hospitals where children of the 0–18-months age groups are treated. In the event of a positive finding this should be notified to some central bureau, together with information about any outbreaks of gastro-enteritis in these hospitals, and these facts should be redistributed to all the paediatric centres. This is probably not possible throughout the country as a whole, but it might be organized on an area basis. In this way children applying for admission, with vomiting, and/or diarrhoea, could be referred back to the hospital in which they had previously been in-patients, if that hospital was known to have an epidemic of gastro-enteritis in progress.

Perhaps some epidemics, such as have been described, could be avoided by the adoption of such a scheme of notification. Vomiting is emphasized as being a symptom that may be presented by patients carrying these type strains of *Bact. coli*. The third epidemic was started in two hospitals by patients who, on admission, were suffering from vomiting but no diarrhoea: Hospital D by VB, the Parsons' block, second floor, by PF. Also in this epidemic there was M who only suffered from vomiting. In the second epidemic patient DI, and in the first epidemic patient HQ, both attended the out-patient department at the Birmingham Children's Hospital with vomiting as their chief symptom.

It is felt that some of the evidence presented here adds to the suggestion, on epidemiological grounds, that the α - and β -types of *Bact. coli* have an aetiological significance in some outbreaks of infantile gastro-enteritis. This is especially suggested by the patients who developed gastro-enteritis following the admission of the infant RN to Hospital K, all of whom started their enteritis within the same 3-day period and in Hospital D when three infants developed enteritis within 2-days of each other, following VB's short stay of 4 days. Also when cultural examinations are made regularly on all infants in the wards, as in the wards of the Birmingham Children's Hospital, they show how often these organisms can be isolated several days before the onset of gastro-intestinal symptoms.

SUMMARY

Evidence of how epidemics of infantile gastro-enteritis can spread from one hospital to at least three other hospitals has been presented. Three such outbreaks are described, in two of which the α -type of *Bact. coli*, and in one the β -type of *Bact. coli*, were associated with the cases of enteritis.

It is suggested that in hospitals which admit infants routine examination of the infants' faeces should be made to identify these types of *Bact. coli*, and that institutional epidemics of gastro-enteritis should be notified to a central bureau together with the cultural findings, so that the pooled knowledge could be redistributed to paediatric centres.

The aetiological relationship between infantile gastro-enteritis and these type strains of *Bact. coli* is briefly discussed.

This work has been made possible by co-operation of the paediatricians in the Birmingham area of the Midlands, and of the consultants at the Birmingham Children's Hospital, and by the kindness of the pathologists of the hospitals concerned in allowing investigation of their patients.

REFERENCES

- ROGERS, K. B. (1951*a*). The spread of infantile gastro-enteritis in a cubicle ward. *J. Hyg., Camb.*, **49**, 140.
ROGERS, K. B. (1951*b*). Discussion on infantile gastro-enteritis. *Proc. R. Soc. Med.* **44**, 519.

(*MS. received for publication 20. I. 51.*)