in excess of coliform bacilli when specimens were taken from infants receiving artificial feeds than when they came from infants who were receiving breast milk only at the time of examination. Although coliform bacilli were not isolated from some feeds and ingredients tested, the differences observed suggested that the bacilli might have been introduced with the feeds. Whether they were introduced in that way or from some other source, the higher incidence of coliform bacilli and their preponderance in the faeces of artificially fed infants may have been due to changes in the intestinal environment of these infants.

Films from rectal swabs stained by Gram's method were examined and rough quantitative estimates were made of the numbers of lactobacilli, Gram-negative bacilli, and Gram-positive cocci. Variations were found with infants of different ages and on different feeding regimes.

It is suggested that the methods used in this study might be applied to field investigations of outbreaks of neonatal diarrhoea as a preliminary to typing of organisms and that they might help to direct investigations of the source and mode of spread of infection in the infant community.

This study was planned as part of a combined clinical and bacteriological study of infections in newborn infants. We wish to thank Dr. Janet Roscoe for taking swabs and for keeping clinical records for use in the analysis of the bacteriological findings. We are also indebted to Dr. Joan Boissard for grouping some streptococci in the early part of the investigation.

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INCIDENCE OF INFECTIONS IN INFANTS IN TWO MATERNITY UNITS

BY

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Since May, 1947, all infections and illness, however trivial, occurring in the babies of two maternity units in Cambridge have been carefully recorded. Unit A took all normal obstetric bookings; Unit B took the abnormal obstetric patients. In each ward day-by-day charts have been kept of the number of mothers, the number of live births, the number of babies in the nursery, and the number of these which were premature. Any infection which has occurred among the babies, the mothers, or the staff has also been recorded on these charts. Bacteriological investigations of the infected cases were undertaken by the Public Health Laboratory Service, Cambridge. In addition throat and rectal swabs of every baby in the ward were taken at intervals throughout the year. These results form the basis of a separate report by McFarlan *et al.* (see p. 1140 of this issue).

I saw all the infected babies. A detailed analysis has been made covering the period from May, 1947, to April, 1948. The infection rate in Unit A was 8.3% (104 infected babies in 1,257 live births); in Unit B the infection rate was 10.3% (19 infected babies in 185 live births) (Table I). It should be emphasized that the slightest evidence of infection was recorded as such; the smallest single pustule, or a

*This work was undertaken while holding a grant from the Medical Research Council.

TABLE I.—Analysis of Infections

	Unit A					Unit B
	By Wards				Total	
	VIIA	VIIIB	IV	VI		
Eyes	20	19	20	9	68 (5.4%)	3 (1.6%)
Skin	4	12*	9	1	26*(2.1%)	8* (4.3%)
Umbilical discharge	1	—	—	—	1	—
Rhinitis	—	2*	—	—	2*	4*
Otitis media	—	—	—	—	—	3
Thrush	1	—	3	—	4	—
Pneumonia	1	—	1	—	2	—
Green stools (± vomit)	—	2	1	—	3	1
Chicken-pox	—	—	—	—	—	1
Total	27	33*	34	10	104*(8.3%)	19*(10.3%)
Live births	391	343	367	156	1,257	185

* Three babies had two infections at the same time—two in ward VIIB and one in Unit B. The totals are therefore adjusted accordingly.

sticky eye if it remained sticky for longer than 24 hours, was recorded even if no pathogen was grown from the swab.

Table II shows the distribution of infections in Unit A according to wards, with the number of live births, by four-week periods. It will be seen that the infections occurred

TABLE II.—Time Distribution of Infections in Unit A

	Total Infections	Total Births	Wards							
			VIIA		VIIB		IV		VI	
			I.	B.	I.	B.	I.	B.	I.	B.
1947										
May 18–June 14	6	87	1	23	4	27	1	37	—	—
June 15–July 12	9	100	5	37	3	25	1	22	0	16
July 13–Aug. 9	3	84	1	24	1	25	1	26	0	9
Aug. 10–Sept. 6	11	89	3	30	5	29	2	27	1	3
Sept. 7–Oct. 4	8	106	3	33	2	29	2	31	1	13
Oct. 5–Nov. 1	2	80	0	29	0	22	1	25	1	4
Nov. 2–Nov. 29	6	120	0	35	2	28	3	35	1	22
Nov. 30–Dec. 27	7	94	2	32	0	19	4	27	1	16
1948										
Dec. 28–Jan. 24	10	84	3	26	1	24	6	21	0	13
Jan. 25–Feb. 21	3	94	1	31	1	28	1	23	0	12
Feb. 22–Mar. 20	17	107	3	29	9	35	3	31	2	12
Mar. 21–Apr. 17	13	118	2	36	5	31	5	32	1	19
Apr. 18–May 15	9	94	3	26	0	21	4	30	2	17
Total	104	1,257	27	391	33	343	34	367	10	156

I. = Infections. B. = Births.

more or less sporadically throughout the year, apart from a sudden increase in VIIB early in 1948, when there was a small epidemic of spots and sticky eyes at the beginning of March. This was controlled by barrier nursing precautions and the use of penicillin and sulphadimidine (sulphamezathine). None of the babies affected was ill and the nursery was not closed.

Very few upper respiratory tract infections and no intestinal upsets amongst the mothers or staff were reported during the year under review. It seems likely that this may have been a factor in the reasonably low infection rate amongst the infants. That there was no consistent rise of infections corresponding with increased business of the ward, as shown by live births, means no more than that there was adequate staff and space for potential cross-infection to remain controlled.

In Unit A 20 infant deaths occurred during the year covered; none was attributable to infection. Post-mortem examinations were made on 10 of these. Seven of the others were very premature (2–3½ lb. (0.9–1.6 kg.) birth weight) and died within a few hours of birth; the other three had severe congenital abnormalities and died within a few days. In this unit the only infection which caused serious illness was pneumonia; two babies were affected, one being a premature infant of 3 lb. (1.36 kg.), but both eventually recovered.

In Unit B three babies recovered from one infection only to get another later; these were counted as separate infections: the total of 19 infections therefore implicates only 16 babies. These infections also were spread fairly evenly through the year. One death was attributable to infection: the baby was the eighth child of the family and obviously premature, though the dates were unreliable and birth weight was 5½ lb. (2.5 kg.). He never would suck and had to be tube-fed. When a fortnight old he suddenly lost 9 oz. (0.25 kg.) in 24 hours and showed signs of otitis media. *Staph. aureus* was grown from the throat. In spite of penicillin, sulphadimidine, and intravenous therapy for 12 days, he died. Post-mortem examination revealed pus in both mastoid cavities from which *Bact. coli* was grown. The other two cases of otitis media occurred four months later at ten days' interval; one was a premature baby of 3 lb. 2 oz. (1.39 kg.) whose ear discharged spontaneously. Neither appeared seriously upset by their infection, and both cases cleared satisfactorily.

Accommodation and Staffing

These have such an effect on cross-infection in any hospital that it is important to give details for comparative purposes. From the following description it will be apparent that the staff were working under conditions less than ideal.

Unit A

Accommodation.—Fifty-six mothers could be accommodated. Only normal cases were booked. These were divided between four wards as follows:

Ward	Mothers	Floor Area of Nursery	Potential Area per Cot
VIIA ..	14	216 sq. ft. (12 × 18)	15.4 sq. ft.
VIIIB ..	14	384 sq. ft. (12 × 32)	27.4 sq. ft.
IV ..	16	1,152 sq. ft. (24 × 48)	72 sq. ft.
VI ..	12	270 sq. ft. (15 × 18)	22.5 sq. ft.

Ward VI was regarded as an overflow; it was opened in June, 1947, and was closed twice during the year under review for two or three weeks each time. It had not its own labour ward; women were therefore delivered in Ward IV or VIIA, the mother and baby then being transferred to Ward VI at once. Each ward had its own nursery in which the babies were nursed in separate cots. It will be realized that the potential cot space varied greatly in the different wards. Ward IV had plenty of space; in Wards VIIIB and VI there was very little space between each cot; and in Ward VIIA the cots almost touched. All the nurseries had good windows. No provision was made for the isolation of infected or premature babies, unless by chance one of the side rooms, of which there were two each on all the wards but VI, happened to be available. Infected babies were therefore usually nursed in a corner of the nursery.

Staff.—Each ward had one sister and one staff nurse; in addition there were pupil midwives (undertaking the first six months of their C.M.B. training)—six on Ward IV and four on each of the other wards. All the nurses attended the mothers and the babies; there were no "nursery nurses" who looked after the babies and no one else. Each ward had also one nursing orderly and one charwoman. The night staff consisted of one sister, four staff nurses, three pupil nurses, and eight assistant nurses. On any one night a total of nine or 10 nurses were distributed round the four units. There was one resident house-surgeon. The medical officer lived out and paid a daily visit.

Nursery Technique.—Masks of one sort or another had to be worn by anyone entering the nursery; but in fact the mask "drill" had been somewhat neglected and masking had become perfunctory. Gowns were not worn. At birth sulphacetamide drops were instilled into the eyes; the baby was then bathed and weighed. Two days later it was bathed and weighed again,

and thereafter daily. Each nursery had, next to the basin, a bathing-table covered with a mackintosh and sheet, on which the baby was placed on his own towel for bathing or changing. The basin was mopped round with "ibcol" between each bathing. The buttock ointment was kept in a communal jar but was extracted with a small square of lint, a separate piece for each baby, so that the nurses' fingers should not touch the ointment. After changing, the soiled napkins and clothes were dropped in a bucket; after feed-time these were taken to the sluice-room, where the nurses rinsed them in plain water before sending them to the common laundry. Babies were taken to and from their mothers, one under each arm, at feed-times. Mothers did not mask unless they had a cold or sore throat. There was no special routine care of mothers' breasts or hands. The nursery floors were swept once a day.

Feeding.—Until January, 1948, all babies were offered, after each breast-feed for the first three days of life, a complementary feed of a dried milk preparation which, when reconstituted, had a relatively high carbohydrate percentage. This was given by a nurse or the mother by cup and spoon. From January, 1948, two wards continued this practice, while the other two gave no complementary feeds or fluids except in special cases. When complementary or supplementary feeds were used they were made up in the ward kitchen. There was no milk kitchen. Bottles and teats were boiled in a fish-kettle on the gas-stove.

Unit B

Accommodation.—This unit was the maternity unit in the general hospital. The intention was that only abnormal obstetric cases should be admitted. There were two lying-in wards, taking six and four women respectively. The only nursery was very small (10 ft. 6 in. by 13 ft.—3.2 by 3.96 m.) with one window facing north. There were nine cots, which were packed in threes on three trolleys; the sides of the cots were touching and there was barely 1 ft. (30 cm.) floor space between the trolleys. Infected or premature babies could not be properly isolated; the bathroom (sister's office) was used in conjunction with an oxygen box as the only place available away from the nursery.

Staff.—A nursery nurse attended to the babies, but when she was off duty or needed assistance one of the pupil nurses on the unit came into the nursery to help. At night there was only one nurse for the whole unit; she attended to the mothers and babies. One ward maid "charred" for the unit. A paediatrician attended daily.

Nursery Technique.—Masks were worn in the nursery, but here again masking had become careless. There was one gown per infant, which was worn for washing or changing or artificial-feeding that infant; when taken off it was rolled up and put on top of the baby's basket on the trolley underneath the cots. These baskets were therefore closely packed. Babies were weighed at birth, again on the third day, and thereafter daily. They were bathed at birth, then "topped and tailed" daily until the cord came off, and thereafter were bathed daily. Bathing and changing were done on the nurse's lap. The floor of the nursery was polished parquet. During the daily sweep and polish the trolleys were pulled out into the corridor and the cots on them covered with a single layer of butter muslin. Otherwise the technique was similar to that described for Unit A.

Feeding.—According to the mother's condition the baby was put to the breast after 24 to 48 hours. Until then boiled water was given. This, and the artificial feeds given when necessary, were prepared in the ward kitchen. Bottles and teats were boiled in a fish-kettle on the gas-stove.

Discussion

It is interesting to compare infection rates amongst the babies of maternity units in different parts of the country from time to time. Various earlier reports (Henderson, 1943; Corner, 1946; Department of Health for Scotland, 1947) have recorded infection rates for neonatal units of

between 20% and 30%. While the present report was in progress another was published (Frazer, 1948) which is salutary to all who had been achieving rates of about 10%, for in Belfast the commendably low figure of under 3% was reached. So far as can be ascertained the criteria of infection used by each observer were similar to those employed at Cambridge.

It will be appreciated from Table III that eye infections are usually the most prevalent and skin infections next so. However, Frazer's figures and those of Unit B show skin

TABLE III.—Records of Neonatal Infection Rates

	Cambridge 1947-8		Edinburgh (Henderson, 1943) 1940-2	Bristol (Corner, 1946) 1944-5		London St. Heller* 1945	Belfast (Frazer, 1948) 1946-7
	Unit A	Unit B		A	B		
Total live births	1,257	185	8,075	3,344	3,190	1,293	2,274
Total infections	8.28%	10.28%	29.8%	25.9%	29.7%	21%	2.77%
Eye infections ..	5.4%	1.62%	15.9%	13.49%	17.6%		0.61%
Skin infections ..	2.06%	4.32%	6.8%	6.58%	10%		1.58%
Thrush ..	0.32%	0	4.9%				0.35%

* Department of Health for Scotland Report, 1947, p. 24.

infections to be nearly three times more common than eye infections. It is therefore interesting to conjecture whether the covering of the cot with gauze as practised by Frazer, which minimizes dust-borne infection, and the removal of the babies during the cleaning of the ward in Unit B in Cambridge had any part in the reversal of the usual finding.

The incidence of infections in hospital nurseries must be related to the quality and number of staff available. However, it would also seem likely that the architectural arrangements of the unit are of great importance. In the Belfast Maternity Home (Frazer, 1948) the basic units accommodated five or six mothers and babies, and the number of deliveries was such that a unit could be filled within 24 hours, allowing a thorough cleaning and airing of each unit for 24 hours between each intake. These arrangements would seem to be a factor in reducing cross-infections. These small units are very different from the large nursery for 50 babies described by Corner, even though the Bristol nursery was partially divided into three sections. In the Edinburgh nurseries, on which Henderson reported, a large number of babies are also collected in one room (personal communication).

These observations suggest that one way of reducing the hospital neonatal infection rate would be to reduce the number of babies in each nursery unit. By reducing the infection rate among newly born infants the death rate from infection in this age group should also be reduced. Infections are responsible for over 25% (Department of Health for Scotland, 1947) of neonatal deaths, and they are the most readily preventable cause.

I would like to thank Dr. Allan McFarlan, Dr. French, and the staff of the County Maternity Unit for their help and co-operation.

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THE RELATION OF STAPHYLOCOCCUS PYOGENES TO INFANTILE DIARRHOEA AND VOMITING*

BY

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The aetiology of infantile diarrhoea and vomiting remains obscure despite the efforts of many investigators. Amongst the many suggested causative bacterial agents mentioned is the staphylococcus. The purpose of this paper is to present the findings in an investigation to determine whether *Staphylococcus pyogenes* was a possible direct cause of the gastro-intestinal condition. The staphylococcus in relation to parenteral infection as a cause of diarrhoea and vomiting is not considered.

Draper and Brown (1946) recorded the presence of *Staph. aureus* in the stools in 26.5% of infants aged 0-1 year suffering from enteritis. One death occurred, in a child 8 months of age who had had a history of diarrhoea for six weeks before admission to hospital and died nine days later; the faeces contained pus and mucus. Felsen and Wolarsky (1942) reported an outbreak of epidemic diarrhoea of the newborn in 19 babies; they found *Staph. aureus* in pure culture in two cases, and it was the predominating organism in a third case. These authors suggested that the presence of *Staph. aureus* was significant, but they were uncertain whether their evidence was sufficient to incriminate any single bacterial agent. Kramer (1948) reported a fatal case of enteritis in a child aged 6 weeks, and described the condition as one of staphylococcal enteritis on the finding of a coagulase-positive streptomycin-resistant *Staph. aureus* from the terminal ileum at necropsy. *Staph. aureus* was not cultured before the child's death.

Crowley *et al.* (1941), in their investigation of epidemic neonatal diarrhoea in maternity hospitals, found a coagulase-positive *Staph. aureus* in two cases in a series of 10 infants. They concluded from the evidence that there was nothing to justify the claim that the staphylococcus was anything more than a possible cause in some outbreaks. Taylor *et al.* (1949), in a series of 19 babies in two outbreaks of infantile diarrhoea and vomiting, found *Staph. pyogenes* in the stools on six occasions, and showed by phage-typing that the staphylococci did not belong to the types commonly present in staphylococcal food-poisoning. Because they found a low incidence and a sparsity of staphylococci in rectal swabs they discontinued further phage-typing.

The incidence of staphylococci in the stools of normal infants has been recorded by Duncan and Walker (1942), who found *Staph. aureus* in 74.4% of 61 newly born infants (method of isolation not stated), and by Martyn (1949), who, using a selective medium for the isolation of staphylococci, reported the presence of *Staph. pyogenes* in 50% of 130 healthy infants aged 0-7 days. Crowley *et al.* (1941) isolated *Staph. aureus* once in 57 normal breast-fed infants aged 3-23 days.

*This work was undertaken whilst holding the Cow and Gate Research Fellowship in Child Health, University of Manchester.