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THE STAPHYLOCOCCUS AND THE NEWBORN CHILD*

BY

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"Begin at the beginning," the King said gravely.

LEWIS CARROLL, *Alice in Wonderland*

The subject matter of this paper is taken from an extensive survey of staphylococcal infection and staphylococcal disease in infants born in the multi-storied maternity wing of a 438-bed general hospital serving a rural industrial city of 95,000 inhabitants and approximately 60 general practitioners.

The maternity wing was completed in 1953 and is situated quite separately from the general hospital; it has 95 beds in single rooms, two-bed and four-bed wards, and one eight-bed ward. There is a well-equipped delivery suite containing eight individual labour rooms and a modern operating-theatre where only obstetrical surgery is performed. There is a general nursery on each floor and a central premature nursery on the first floor. The general nurseries are all similar and vary from 342 to 432 sq. ft. (31.8 to 40.1 sq. m.) in area, and each has a changing and food-preparation room attached.

Approximately 2,400 deliveries are conducted each year in this hospital, and the present study includes all newborn babies in the first 10 days of life if in hospital. The average period of stay in hospital of each baby was eight days.

Bacteriological Methods

Any reference to the staphylococcus refers to a coagulase-positive *Staphylococcus aureus* unless otherwise stated.

All swabbings were taken with cotton-wool swabs moistened in peptone water and were plated on horse-blood-agar and read after overnight incubation at 37° C. Every swab was also inoculated into nutrient broth which, after incubation for 24 hours, was plated on to another horse-blood-agar plate. Since January, 1959, the nutrient broth has been replaced by "salty broth" (nutrient broth with 6% (w/v) NaCl added).

With the introduction of hexachlorophane emulsion into the maternity wing in January, 1960, all swabs were, in addition, plated on to a nutrient agar plate containing 1% (v/v) polysorbate 80 (Lawrence and Erlandson, 1953; Smylie *et al.*, 1959).

All staphylococci isolated were tested for coagulase reaction by the slide technique, using human plasma (Cadness-Graves *et al.*, 1943). If this was negative the strain was further tested by the tube technique, using 1:10 human plasma.

All swabs which yielded a coagulase-positive *Staph. aureus* were counted as positive. Included among these were swabs yielding small numbers of staphylococci revealed only by the nutrient-broth or "salty"-broth culture.

All strains of staphylococci were tested for varying antibiotic sensitivities by using "sentest" disks.

882 strains of the staphylococci isolated were phage-typed by the method of Williams and Rippon (1952), with the addition of phages 71, 80, and 81. The term "phage pattern 80/81" is used for convenience to include the strains typing as 52/80/81, 52/52A/80/81, 80, 80/81, and 81, as all these strains are closely related (Asheshov and Rippon, 1959; Rountree, 1959).

Observations in 1956 and 1957

Surveys performed in 1956 and 1957 (Plueckhahn and Banks, 1958, 1961) showed that 41% of babies born developed clinical evidence of staphylococcal disease and 100% of babies 5 days old carried the staphylococcus.

Of particular note was the busy life of the babies, who were repeatedly handled by various staff. It was routine for each infant to be fully bathed daily, weighed at each feeding, and to have an "eye-toilet" four-hourly. Between these procedures the babies slept in

TABLE I.—Miscellaneous Areas from which *Staphylococci* were Isolated in 1956 and 1957

Site of Culture	Swabs Taken	<i>Staph. Aureus</i> Grown
Delivery rooms:		
Infant "suckers" and cord ties	9	3
Wash-basin ledges and floor	8	2
Nurseries:		
Door handles	19	2
Empty cots	5	1
Floor	16	11
Changing-rooms:		
Changing-bench	24	9
Baths	11	5
Scales	8	4
Pen for recording weight	3	3
Cotton-wool bins and various bottles ..	41	12
Door handles and window ledges	11	4
Floor	7	5
Mothers:		
Breast pumps	3	—
Lavatories—door handles	12	2
Sheets	6	2
Bedroom floor	6	4
Nurses:		
Towels	10	5
Wash-basin levers and door handles ..	27	2
Telephone	1	1
Laundry:		
Bags and bins	10	2
Bulk laundry—"dirty"	11	6
"clean"	8	—
Total	256	85 (33%)

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attractively painted community nurseries in which the air was kept moving by the coming and going of nursing and medical staff, by cots being made, babies being changed, and dirty linen being sorted. All these things greatly increased the ease of transmission of the ubiquitous staphylococcus (Table I).

Many changes in the conduct of the maternity wing were adopted as a result of these surveys (Plueckhahn and Banks, 1961) and were effected, except for "rooming-in," by May, 1957. Special "rooming-in" cots were purchased in June, 1958, and from this time the babies were removed from the central nurseries after the first 24 hours of life and then entirely cared for by their mothers. The only exceptions were for medical reasons concerning either the mother or the baby, and these occurred in approximately 5% of all deliveries.

Incidence of Staphylococcal Disease in 1957-9

All babies born after April, 1957, were examined daily while in hospital for signs of staphylococcal disease. The incidence is shown in Table II.

TABLE II.—Infection Rate in Babies Grouped in Three-month Periods from April, 1957, to December, 1959

Time	Babies Born	Infected Babies
1957:		
April-June	557	193 (34.7%)
July-September .. .	616	207 (33.6%)
October-December ..	654	216 (33.0%)
1958:		
January-March	609	156 (25.6%)
April-June	508	87 (17.1%)
July-September .. .	591	83 (14.7%)
October-December ..	615	49 (7.9%)
1959:		
January-March	594	54 (9.1%)
April-June	559	100 (17.9%)
July-September .. .	607	75 (12.4%)
October-December ..	633	67 (10.6%)
Total	6,543	1,287 (19.7%)

A decrease in incidence of staphylococcal disease in the newborn slowly followed the initial changes in the conduct of the maternity wing, and there was a further rapid decrease in incidence with the adoption of "rooming-in" (Fig. 1). The improvement was maintained until April, 1959, when there was a sharp increase in the

incidence of minor staphylococcal lesions. Investigation showed that this rise started in March, 1959, when the nursing staff were instructed to move the babies and cots back into the nurseries during visiting periods and nights—in other words, the beginning of the breakdown of "rooming-in." This was precipitated by isolated complaints of babies being handled by visitors. Full "rooming-in" was reinstituted in July, 1959, and was followed by another decrease in the incidence of staphylococcal disease.

The "carrier rate" of staphylococci was assessed by taking swabbings from the eyes, nose, and umbilicus of all normal babies up to 10 days old in the maternity wing on two days in May and September, 1957, and again in May and October, 1959. These surveys showed that despite the lessening in staphylococcal disease the carrier rate remained virtually the same (Table III).

TABLE III.—Carrier Rate of Infants, 1957-9

Age of Babies	No. Swabbed	Staph. aureus Isolated	Site of Positive Swabs		
			Eyes	Umbilicus	Nose
At birth	20	3	2	1	2
1-24 hours	27	12	1	11	3
2 days	38	30	13	22	9
3-4	72	64	33	51	35
5-6	88	85	56	60	59
7-10	91	84	48	64	68
3 weeks	19	14	12	7	10
6	19	13	11	10	10

1960—Chemical Substances Used on Skin of Infants

Many workers have studied the application of substances such as hexachlorophane and chlorhexidine to the skin of the baby in attempts to kill any staphylococcus lodging there (Hardymont, 1954; Gillespie *et al.*, 1958; Hill *et al.*, 1959; Simpson *et al.*, 1960). Hill *et al.*, at the Royal Women's Hospital, Melbourne, by "dry washing" babies with hexachlorophane emulsion, reported a reduction in staphylococcal disease in six months from 15% to 1.3% of the babies born.

The results were convincing, but I thought that other factors might play as large a part as the chemical substance itself. For instance, the use of special methods keeps the problem constantly before all people

FIG. 1

FIG. 2

FIG. 3

FIG. 1.—Incidence, in three-monthly periods, of staphylococcal disease in babies. The sharp drop in incidence after a review of nursing methods and education of staff in March, 1957, is clearly shown. The effect of commencing and ceasing "rooming-in" in 1958 and 1959, and the effects of dry washing with phisohehex and the Geelong Hospital emulsion in 1960 are also shown. FIG. 2.—Compiled from data in Tables III, VI, and VII. Infant carrier rates in hospital in 1957-9 are compared with those of 1960. The comparison clearly shows the much lower infant carrier rate present when phisohehex is used for dry washing. FIG. 3.—Incidence of skin lesions in 1959 and 1960. The sharp decrease in incidence due to dry washing with phisohehex in 1960 is clearly shown.

handling the babies and will result in added care and vigilance and better observation of the first principles of asepsis. In addition, the coating of the skin with a protective layer (cf. vernix caseosa) may in itself, without antiseptic substances, protect the skin from minor trauma and so lower the incidence of staphylococcal skin lesions in the newborn.

In January, 1960, an emulsion with the following formula was prepared in the pharmacy of the Geelong and District Hospital:

Arachis oil	50 ml.
Adeps lanae	22 g.
"Lanette wax N"	67 g.
Glycerin	67 g.
Alkethoz "lissapol" (detergent)	20 ml.
Oil of neroli (perfume)	1.2 ml.
Distilled water	870 ml.

This emulsion was almost identical in appearance and consistency to the commercially manufactured hexachlorophane emulsion ("phisohex") but left a slightly greasy covering on the skin after application and contained no hexachlorophane.

As from January, 1960, all babies born in the maternity wing were "dry washed" in a manner similar to that used by Hill *et al.* (1959) in the application of hexachlorophane emulsion to babies at the Royal Women's Hospital, Melbourne. The ground and second floors were supplied with phisohex. The first and third floors were supplied with the Geelong Hospital emulsion. Nursing procedure was identical on all floors.

The medical profession and nursing staff were told that both emulsions were chemically identical and that the only difference was that the Geelong Hospital emulsion was prepared in the hospital pharmacy and consequently was much cheaper. It was explained that the purpose of the experiment was to test the relative merits of the two preparations, and all concerned were under the impression that both preparations contained hexachlorophane.

On April 1, 1960, all dispensers and stock bottles were cleaned out and the emulsions were reversed on the respective floors. A similar change occurred on July 1 and October 1, and so each floor used each emulsion for a period of six months.

Dry washing was rapidly followed by an overall decrease in staphylococcal disease in infants. The decrease in the number of skin lesions was most obvious (Table IV).

A comparison of the emulsions showed that phisohex was the more effective and its effect was particularly evident in lowering the incidence of staphylococcal skin lesions in the newborn (Table V).

TABLE IV.—Incidence of Staphylococcal Disease in Newborn January–December, 1960

1960	Babies Born	Staphylococcal Disease	
		All Lesions	Skin Lesions
January–March	629	3.7%	0.64%
April–June	628	6.5%	2.7%
July–September	671	5.2%	2.8%
October–December	639	7.2%	3.1%

TABLE V.—Incidence of Staphylococcal Disease in Newborn January–December, 1960

	Infants	All Lesions	Skin Lesions
Infants "dry washed" with phisohex	1,266	58 (4.6%)	15 (1.2%)
Hospital emulsion "	1,301	87 (6.7%)	45 (3.4%)

"Carrier Rate" of Staphylococci During Dry Washing

Swabs were taken at delivery from both eyes, the nose, and umbilicus of 10 consecutive babies born during each month from February to July inclusive, and of nine babies born in August, 1960. There was no selection of these 69 babies, and after delivery 36 went to floors using the Geelong Hospital emulsion and 33 to floors using phisohex. Swabs were again taken from all sites within 48 hours of delivery, again on the third or fourth day, then on the fifth or sixth day, and finally, if still in hospital, on the seventh, eighth, ninth, or tenth day. The swabbings were repeated at home during the third and the sixth week after birth.

Tables VI and VII show respectively the carrier rate of infants dry washed with phisohex and those with the Geelong Hospital emulsion.

TABLE VI.—Carrier Rate of Infants Dry Washed with Phisohex

Age of Babies	No. Swabbed	Staph. aureus Isolated	Site of Positive Swabs			
			Eyes	Umbilicus	Nose	Total
At birth	33	3	2	—	1	3
1–24 hours	20	3	—	3	—	3
2 days	13	3	1	2	2	4
3–4	33	15	8	11	7	26
5–6	33	13	5	11	10	26
7–10	22	10	6	7	9	22
3 weeks	29	15	5	10	12	27
6	29	15	9	9	12	30

TABLE VII.—Carrier Rate of Infants Dry Washed with Geelong Hospital Emulsion

Age of Babies	No. Swabbed	Staph. aureus Isolated	Site of Positive Swabs			
			Eyes	Umbilicus	Nose	Total
At birth	36	4	1	—	3	4
1–24 hours	19	8	2	4	6	12
2 days	17	8	3	6	2	11
3 and 4 days	36	25	13	14	8	35
5 and 6	30	22	14	18	12	44
7–10	27	20	16	9	18	43
3 weeks	29	23	10	13	12	35
6	29	22	10	11	18	39

The findings showed that although the overall carrier rate remained high in 1960 there was a marked decrease over that of 1957–9 (Table III) and that the presence of hexachlorophane in the emulsion used for dry washing babies was more effective in lowering the infant carrier rate than dry washing without added hexachlorophane. Fig. 2 compares the relative carrier rates.

Infant Carrier Rate Within 24 Hours of Birth

Swabs were taken in 1959 and 1960 from 89 babies at birth and again from 66 of these within 24 hours of delivery. Table VIII shows that 11.2% of babies were

TABLE VIII.—Infant Carrier Rate Within 24 Hours of Birth

Age of Babies	No. Swabbed	Staph. aureus Isolated	Site of Positive Swabs		
			Eyes	Umbilicus	Nose
At birth	89	10 (11.2%)	5	—	6
1–24 hours	66	23 (34.8%)	4	18	9

carriers of the staphylococcus within minutes of birth. The possible source of these staphylococci must be the mother's vagina or the labour ward and its staff.

Bret and Coupe (1959) are of the opinion that in 12.5% of confinements the infant is infected with staphylococci from its mother's vagina; they found that 15% of 300 consecutive mothers investigated by them

were carriers of pathogenic staphylococci in their vaginas at confinement. I am of the opinion that the vagina plays only a minor part in infecting the baby with staphylococci at birth; I grew a staphylococcus from only one out of 100 consecutive mothers swabbed from the vagina on commencing the final stages of labour. This is in agreement with the findings of Wysham *et al.* (1957), who grew no coagulase-positive staphylococci from vaginal cultures taken from 99 mothers just after delivery. It appears that searching for and treating vaginitis in pregnant women as suggested by Bret and Coupe (1959) would play little if any part in the prophylaxis of staphylococcal disease in the newborn.

The staphylococci occurring in the "carrier state" on babies at birth and within the first 24 hours of life must be introduced either from the mother's vagina or from the environment of the maternity hospital or from its staff. Some of these staphylococci are undoubtedly air-borne, but others are most certainly introduced by direct contact from procedures carried out at birth. Many of the procedures, such as tying the cord and removing mucus from the pharynx, are unavoidable, but some procedures, such as wiping the eyes, are probably not only unnecessary but also dangerous.

Discussion

The results are only a few aspects of an extensive study of staphylococcal disease in the newborn which was begun four years ago with the aim of investigating an impression that strains of staphylococci of enhanced pathogenicity for man were becoming increasingly prevalent throughout Geelong and its surrounding district, and, in particular, in the maternity wing of the Geelong and District Hospital.

Henderson (1943) made the following statement in a Honyman Gillespie Lecture: "The *Staphylococcus aureus* is the commonest cause of neonatal infection in maternity hospitals, and it causes a great variety of lesions." Table IX is taken from that lecture and shows

TABLE IX.—Incidence of Various Types of Staphylococcal Infection (Based on Type of Initial Lesion) in 424 Infants in 1942 (From Henderson, 1943)

Type of Lesion	No. of Cases	Incidence %
Conjunctivitis	212*	50.0
Pustules	115	27.1
Paronychia	53	12.5
Bullous impetigo	26	6.1
Boils	10	2.4
Cellulitis and abscesses	5	1.2
Pneumonia	3	0.7

* Equivalent to 106 in six months of accurate recording.

the incidence of the various types of lesions in the 424 cases of staphylococcal disease of the newborn occurring in the Simpson Maternity Hospital, Edinburgh, in 1942. These 424 cases of staphylococcal disease of the newborn occurred in approximately 2,800 deliveries. It is not possible to make an exact comparison, but there were 2,900 deliveries in our maternity wing between January 1, 1958, and March 25, 1959, and 420 of these babies developed staphylococcal disease in the first 10 days of life (Table II). An attempt is made in Table X to classify these lesions in the same way as in Table IX.

These findings are in agreement with those of Walsh McDermott (1956), who said, "We have no convincing evidence, or indeed any particular well founded suspicion, that the crude equilibrium between the public at large and the ubiquitous staphylococcus is shifting

TABLE X.—Incidence of Various Types of Staphylococcal Infection (Based on Type of Initial Lesion) in 420 Infants in 1958-9

Type of Lesion	No. of Cases	Incidence %
Conjunctivitis	186	44.3
Pustules	212	50.5
Paronychia	16	3.8
Bullous impetigo	1	0.2
Boils, cellulitis, and abscesses	3	0.7
Pneumonia	2	0.5

for the worse." Despite the truth of this statement, there is a problem in maternity units, and staphylococcal lesions are now the most troublesome and disturbing infection with which epidemiologists and obstetricians have to contend.

One of the most complex factors in attempting to assess the various aspects of staphylococcal infection as they apply to the newborn in large maternity units is the complete ubiquitousness of the staphylococcus and its multiple methods of transmission to the newborn (Plueckhahn and Banks, 1961) and the impossibility of preventing some cross-infection.

Hospital Design

The relative importance of the various means of transmission of the staphylococcus is affected in part by both the method of conduct of the hospital and its construction. It is rational to consider that the modern trend of building large hospitals with communal nurseries will increase the possible avenues of cross-infection. Henderson (1943) was among the first to point out the possible dangers of building maternity hospitals with large nurseries, and stressed that dispersal of babies may lessen some possible avenues of cross-infection.

In 1945 there were 100 midwifery beds in Geelong and these were contained in 11 separate small hospitals of 5 to 25 beds. In 1955 there were 95 midwifery beds in Geelong and all were in the maternity wing of the Geelong and District Hospital.

The present trend of building large maternity units has certain disadvantages as the dispersal of infants is an important factor in controlling the spread of staphylococcal disease in the newborn. It is admitted that other advantages may outweigh this disadvantage. There are two possible methods of dispersal: (1) Collective dispersal: this is achieved by multiple self-contained small maternity hospitals or wings. (2) Individual dispersal: this can be achieved by home delivery or in a large maternity hospital by "rooming-in."

"Rooming-in"

Whatever the habits of the staphylococcus there are four obvious links in the chain of production of staphylococcal disease in the newborn—the maternity hospital itself, its staff, the mother, and the baby—all must play a greater or lesser part in cross-infection and transmission of the staphylococcus. It stands to reason that if the mother and infant are cared for as a single unit then certain avenues of possible cross-infection will be eliminated, although a further avenue in the form of visitors may be introduced. "Rooming-in" was without doubt a most important fundamental procedure in decreasing staphylococcal disease in this survey (Fig. 1), and it adds an even greater responsibility on the nursing staff to observe strictly the first principles of aseptic technique whenever they intrude into the family unit.

The enforcement of strict "rooming-in" often suffers certain undermining from both the mothers and the nursing staff. Many of the former, particularly those

with a family, regard their respite in hospital as a holiday, or at least as an escape from the cares of running a household and the cries of older children. On the other hand, the obstetric nurse is often attracted to that career by a love of handling newborn babies, and once this is limited or removed much of her interest in maternity nursing goes. There is thus an ever-present need for sympathetic and constant education of both these groups to overcome this problem.

Routine Eye Toilet

It was the practice of the nursing staff and medical practitioners to carry out routine eye toilets in the early days of a baby's life. Experience has shown that routine eye toilets serve no useful purpose in preventing "sticky eyes" but may amount to unnecessary and dangerous interference by increasing the risk of cross-infection and adding a possibility of minor trauma to the conjunctiva and eyelids. The latter may provide a portal of entry as well as a suitable area for localization and multiplication of any staphylococci lodging there.

Hardyment *et al.* (1960) admit to chemical irritation by silver nitrate prophylaxis but think that there is insufficient evidence to justify the discontinuation or replacement of silver nitrate solution for prophylaxis against conjunctivitis. Their grounds for advising this measure are that they believe that after combating "clinical conjunctivitis" due to the staphylococcus their remaining problem was chiefly the prophylaxis of gonorrhoeal ophthalmia. These workers found two cases in 1,724 babies who had no treatment to their eyes. There has been one case of gonorrhoeal ophthalmia in the past four years in Geelong, and the gonococcus does not seem to be a real problem. If gonorrhoeal ophthalmia does occur it is easily combated and stands little chance of spreading to other babies when "rooming-in" is practised.

Antisepsis and the Newborn

The application of antiseptic substances to the skin of the baby has been used in many centres as an ancillary aid to asepsis in the control of staphylococcal disease in the newborn. The substances that have received most attention are hexachlorophane and chlorhexidine (Hardyment, 1954; Wysham *et al.*, 1957; Gillespie *et al.*, 1958; Hill *et al.*, 1959; Green, 1959; Corner *et al.*, 1960).

Hexachlorophane in emulsion plays a definite part in lowering the incidence of infantile staphylococcal disease in hospital and in particular skin sepsis (Table V and Figs. 1 and 3).

1959—151 (6.2%) of 2,433 infants born developed skin lesions.

1960—45 (3.4%) of 1,301 infants dry washed with Geelong Hospital emulsion developed skin lesions.

1960—15 (1.2%) of 1,266 infants dry washed with phisoex developed skin lesions.

A similar effect is shown on the infant carrier rate both in hospital and at home (Fig. 2), and this survey shows the following carrier rates by the fifth and sixth days of life.

1957 (prior to dry washing)—97% of babies.

1960 (dry washing with Geelong Hospital emulsion)—73% of babies.

1960 (dry washing with phisoex)—39% of babies.

The findings show that the use of an "antiseptic umbrella" is a useful complementary aid in the prevention of staphylococcal disease in the newborn even when

asepsis is good, and undoubtedly would be most important in preventing or aborting outbreaks of severe staphylococcal disease in nurseries during temporary breakdowns in aseptic technique or when organisms of increased virulence appear.

There are several answers to most clinical problems, and a powder containing hexachlorophane also reduces the morbidity in infants due to the staphylococcus (Corner *et al.*, 1960). Decreasing the length of stay in hospital may be similarly effective, and the Bradford experiment (Theobald, 1959), in which women whose pregnancies were normal were sent home on the second day, may be as useful in preventing "the baby becoming a culture medium for the staphylococcus" as it was in improving antenatal care and almost eliminating severe pregnancy toxæmia.

Staphylococcal Disease at Home

The maintenance of a low carrier rate in the first few months of life is desirable, and a feature of the epidemiology of many nursery outbreaks has been the number of infants developing the first signs of staphylococcal disease after their discharge from hospital (Colbeck, 1949; Shaffer *et al.*, 1957; National Conference on Hospital-acquired Staphylococcal Disease, 1958; Wentworth *et al.*, 1958a). Apparently the staphylococcus carried home by the newborn infant may act as a focus for an increase in the level of community-acquired staphylococcal disease (Wentworth *et al.*, 1958b; Hurst and Grossman, 1960).

In 1960 those infants involved in the carrier rate surveys at home were examined until 6 weeks old for evidence of staphylococcal disease and showed a high incidence of lesions. This incidence significantly varied with the carrier rate existing on discharge from hospital and at home (Table XI).

TABLE XI.—Percentage of Infants up to 6 Weeks of Age Developing Staphylococcal Lesions at Home

1960	Carrier Rate		Infants with Lesions
	At 8 Days	At 6 Weeks	
Dry washed with phisoex in hospital ..	45.5%	51.7%	10.4%
Dry washed with Geelong Hospital emulsion in hospital ..	74.1%	75.9%	24.1%

Despite the prevalence of minor staphylococcal disease at home and in hospital, the subsequent occurrence of severe staphylococcal disease in the first six months of life has not been common during this study (Table XII). A comparison of this table with Fig. 3 shows that even this low morbidity and mortality in the first six months of life bore a direct relationship to the prevalence of staphylococcal disease in the newborn in hospital.

There is no doubt that when staphylococci are prevalent the subsequent progress of infants on discharge

TABLE XII.—Infants Developing Severe Staphylococcal Disease in First Six Months of Life. July, 1956, to September, 1960

	1956 (6 Mths.)	1957	1958	1959	1960 (9 Mths.)	Total
Infants born in maternity wing ..	1,298	2,419	2,323	2,433	1,928	10,401
No. requiring hospitalization as result of staphylococcal disease ..	6	11	7	7	—	31
Deaths in first six months of life ..	1	4	2	1	—	8*

* The eight deaths were due to : pneumonia in six cases, septicaemia in one, and peritonitis in one.

home is adversely affected and the measures taken to reduce staphylococcal disease in hospital are fully reflected only in the reduced morbidity at home.

Morbidity in Mothers—Breast Abscess

Approximately 90% of mothers were followed up for six months after delivery in order to elicit the incidence of breast abscess (Table XIII). To give an absolute

TABLE XIII.—Incidence of Breast Abscess in Mothers. July, 1956, to September, 1960

	1956 (6 Mths.)	1957	1958	1959	1960 (9 Mths.)	Total
No. of mothers ..	1,091	2,003	2,024	2,320	1,853	9,291
No. of breast abscesses in six months after delivery	27	31	20	18	12	108
Mothers developing breast abscess ..	2.5%	1.5%	1.0%	0.78%	0.60%	1.16%

criterion only those breast abscesses that required incision or suppuration are included in this table, which shows that the incidence of breast abscess remained relatively low even when staphylococcal disease of the newborn was prevalent as in 1956 and 1957. There was a definite decrease in the incidence of breast abscess in mothers in 1958 and 1959 with the decrease in incidence of staphylococcal disease in the newborn. A further decrease to 0.6% occurred in 1960 with the introduction of dry washing. This is similar to the reduction recorded by Corner *et al.* (1960), who reported a fall in incidence of breast abscess in mothers from 2.4% to 0.6% after the use on the babies of a dusting powder containing hexachlorophane.

The Staphylococcus Itself

A review of the accumulated knowledge concerning the staphylococci pathogenic for man was made by Professor Bigger (1937); he expressed the opinion that it was possible that the circumstances of the infection, such as local trauma, pressure, or friction to a part, might play the dominant role in the establishment of staphylococcal disease in man, and the factors directly related to the staphylococcus itself might take the lesser role.

I am convinced from the results of the surveys in the maternity wing that the circumstances of the infection played a much more important part in the production of staphylococcal disease in the newborn in Geelong than any factor directly related to the staphylococcus itself.

Phage-typing of coagulase-positive staphylococci isolated from lesions, and infant carrier rate surveys in the maternity wing, show a scatter over all phage groups (Table XIV).

TABLE XIV.—Phage-group Distribution of Staphylococci Isolated From Lesions and Carrier Rate Surveys in Maternity Wing

Phage Group	Staphylococcal Disease of Newborn	Carrier Rate Surveys
Group I—80/81 ..	8.7%	13.5%
—Others ..	5.2%	4.9%
Group II ..	7.0%	7.0%
.. III ..	20.0%	15.7%
Miscellaneous ..	3.0%	2.7%
Non-typable ..	56.1%	56.2%
Total strains ..	230	370

Phage-typing at no time was of any help in indicating pathogenic properties of a staphylococcus; this is contrary to the experience of Williams (1959), who stated, "The phage-typing results show clearly that differences between staphylococci do exist." Other workers (Barber

and Burston, 1955; Gillespie *et al.*, 1958; Barber, 1960) agree with Williams and believe there is a "striking" difference in the distribution of strains isolated in maternity units and surgical wards. They all found that known strains of phage group I were predominant in maternity units, whereas recognized strains of phage group III were more common in surgical wards. The present study of staphylococcal disease showed that this was not so in Geelong and that the reverse appeared to exist in both the maternity wing and the surgical wards (Tables XIV and XV).

TABLE XV.—Phage-group Distribution of Staphylococci Isolated in Geelong. 1957–60

Phage Group	Maternity Wing	Surgical Wards	Normal Population	Total
Group I { 80/81 ..	11.7%	26.0%	4.7%	14.2%
.. Others ..	5.2%	2.6%	3.5%	4.3%
Group II ..	7.0%	4.6%	11.6%	7.0%
.. III ..	17.3%	9.7%	15.1%	15.4%
Miscellaneous ..	2.8%	2.6%	—	2.5%
Non-typable ..	56.0%	54.5%	65.1%	56.6%
Total strains ..	600	196	86	882

Many workers in Australia and overseas have credited staphylococci of phage pattern 80/81 with a higher degree of virulence for the newborn than staphylococci in general (Rountree and Freeman, 1955; Gillespie and Alder, 1957; Monroe and Markham, 1958; Williams, 1959; Barber, 1960). This has not been evident in Geelong.

The high proportion of non-typable strains lessens the value of phage-typing when used in studying the transmission of the staphylococcus in Geelong but does not detract in the assessment of the relative virulence or importance of phage pattern 80/81 in causing disease in the newborn. If phage pattern 80/81 possessed greater virulence for the newborn than other staphylococci it would be isolated more often from lesions than from the carrier state. This was not so in Geelong (Table XIV). In addition, staphylococci of phage pattern 80/81 were also found more often in lesions from adults than in those from the newborn (Table XV).

At no stage has it been possible to implicate a particular phage type of staphylococcus with the prevalence of staphylococcal disease in the newborn in Geelong, and it appears that the high incidence of infant staphylococcal disease is more intimately associated with factors unrelated to the virulence of the strains of staphylococci isolated.

The size of the bacterial invasion necessary to produce disease in the normal newly born infant appears to be large, and I believe that the prevalence, and thus the number of available viable staphylococci, exerts an important influence on the property of "invasiveness and communicability" (Rowley, 1960) as seen in the staphylococcus. It can be seen that the decrease in the incidence of staphylococcal disease in 1960 was accompanied by a lower infant carrier rate. The correct statement is probably that a lowering of the infant carrier rate below a critical level was accompanied by a decreased incidence of staphylococcal disease in the newborn.

The increase in number of staphylococci need not necessarily be a general increase related to abundant means of transmission, but may be a local increase in the host resulting from a favourable portal of entry caused by any breach in the continuity of an epithelial surface, such as chafed skin, a moist umbilicus, or

scratched conjunctiva. These areas not only provide a better soil than the intact epithelial surface for the multiplication of any staphylococci present but also aid localization of the organism.

Finally, I am convinced that satisfactory methods are available for reducing the number of viable staphylococci on the surfaces of the newborn, and it behoves us not to provide the circumstances to aid local increase of these organisms. I also believe that the presence of a moderate number of viable staphylococci on the newly born infant is not harmful and may even be desirable, as we know practically nothing concerning the early immunological responses of the newborn to the ubiquitous staphylococcus.

Summary

Certain aspects of an extensive bacteriological and clinical survey of staphylococcal infection occurring in the newborn are discussed.

The survey concerns 11,040 infants born in a 95-bed maternity unit between July, 1956, and December, 1960.

Changes in the conduct of this unit resulted in a reduction in minor staphylococcal disease in the newborn from 41.0% in 1956 to 4.7% in 1960. Staphylococcal skin disease itself was reduced from 30.8% to 1.3%.

The three principal factors responsible for the reduction were a restriction of "routine" nursing procedures, "rooming-in," and "dry washing" babies with phisohex.

Dry washing with phisohex is shown to be two and a half times more effective in reducing skin sepsis in hospital and for the first four weeks at home than a similar emulsion containing no hexachlorophane.

Of 10,401 infants followed for six months after birth only 0.3% were readmitted to hospital and 0.077% died as a direct result of staphylococcal disease. Both this morbidity and mortality bore a direct relationship to the occurrence of minor staphylococcal disease in the maternity unit.

The incidence of breast abscess in 9,291 mothers fell from 2.5% in 1956 to 0.6% in 1960.

Phage pattern 80/81 did not play a dominant part in the frequency of minor staphylococcal disease in the newborn in this hospital. The circumstances of the infection appeared more important than the strain of staphylococcus.

I am particularly indebted to Miss Joan Banks, bacteriologist of the Geelong and District Hospital, for much technical assistance and criticism. My thanks are due to the Committee of the Geelong and District Hospital for permitting and providing the facilities for the survey. The survey would not have been possible without the wholehearted support of the medical practitioners in Geelong and surrounding district, who all fully co-operated and allowed complete access to their private and public patients and records.

REFERENCES

- Asheshov, E. H., and Rippon, J. E. (1959). *J. gen. Microbiol.*, **20**, 634.
- Barber, M. (1960). In *Recent Advances in Clinical Pathology*, Series III, p. 2, edited by S. C. Dyke. Churchill, London.
- and Burston, J. (1955). *Lancet*, **2**, 578.
- Bigger, J. W. (1937). *Brit. med. J.*, **2**, 837.
- Bret, J., and Coupe, Cl. (1959). *Presse méd.*, **67**, 216.
- Cadness-Graves, B., Williams, R., Harper, G. J., and Miles, A. A. (1943). *Lancet*, **1**, 736.
- Colbeck, J. C. (1949). *Canad. med. Ass. J.*, **61**, 557.
- Corner, B. D., Crowther, S. T., and Eades, S. M. (1960). *Brit. med. J.*, **1**, 1927.
- Gillespie, W. A., and Alder, V. G. (1957). *Lancet*, **1**, 633.
- Simpson, K., and Tozer, R. C. (1958). *Ibid.*, **2**, 1075.
- Green, K. G. (1959). Personal communication, and I.C.I. Brochure on use of "Naseptin."
- Hardyment, A. F. (1954). *Canad. med. Ass. J.*, **70**, 379.
- Wilson, R. A., Cockcroft, W., and Johnson, B. (1960). *Pediatrics*, **25**, 907.
- Henderson, J. L. (1943). *Edinb. med. J.*, **50**, 535.
- Hill, A. M., Butler, H. M., and Laver, J. C. (1959). *Med. J. Aust.*, **2**, 633.
- Hurst, V., and Grossman, M. (1960). *New Engl. J. Med.*, **262**, 951.
- Lawrence, C. A., and Erlandson, A. L., jun. (1953). *J. Amer. pharm. Ass., sci. Ed.*, **42**, 352.
- McDermott, W. (1956). *Brit. med. J.*, **2**, 837.
- Monro, J. A., and Markham, N. P. (1958). *Lancet*, **2**, 186.
- National Conference on Hospital-acquired Staphylococcal Disease (1958). *Publ. Hlth Rep. (Wash.)*, **73**, 1082.
- Plueckhahn, V. D., and Banks, J. (1958). *Med. J. Aust.*, **1**, 664.
- (1961). *Aust. Ann. Med.*, **10**, 59.
- Rountree, P. M. (1959). *J. gen. Microbiol.*, **20**, 620.
- and Freeman, B. M. (1955). *Med. J. Aust.*, **2**, 157.
- Rowley, D. (1960). *Bact. Rev.*, **24**, 106.
- Shaffer, T. E., Sylvester, R. F., jun., Baldwin, J. N., and Rheins, M. S. (1957). *Amer. J. publ. Hlth*, **47**, 990.
- Simpson, K., Tozer, R. C., and Gillespie, W. A. (1960). *Brit. med. J.*, **1**, 315.
- Smylie, H. G., Webster, C. U., and Bruce, M. L. (1959). *Ibid.*, **2**, 606.
- Theobald, G. W. (1959). *Ibid.*, **2**, 1364.
- Wentworth, F. H., Miller, A. L., and Wentworth, B. B. (1958a). *Amer. J. publ. Hlth*, **48**, 287.
- (1958b). *Publ. Hlth Rep. (Wash.)*, **73**, 1092.
- Williams, R. E. O. (1959). *Lancet*, **1**, 190.
- and Rippon, J. E. (1952). *J. Hyg. (Camb.)*, **50**, 320.
- Wysham, D. N., Mulhern, M. E., Navarre, G. C., La Veck, G. D., Kennan, A. L., and Giedt, W. R. (1957). *New Engl. J. Med.*, **257**, 295.

NEONATAL TETANUS IN NEW GUINEA

EFFECT OF ACTIVE IMMUNIZATION IN PREGNANCY

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Tetanus of the newborn is most likely to occur where midwifery is absent or is performed by untrained people. Therefore reliable figures for the incidence of the disease are usually not available from the countries where they are likely to be highest—the underdeveloped regions of the tropics. Axnick and Alexander (1957), in the United States, found the highest incidence, 34.3 cases per 100,000 live births, among the non-white population of Florida. This contrasts with estimates of "from 5 to 10%" for part of Haiti by Earle and Mellon (1958) and about 11% for the Guachene district of Colombia (Dr. K. W. Newell, 1961, personal communication). The disease is common in Nigeria (Jelliffe, 1950; Tompkins, 1958); and Stahlie (1960) estimated that it caused at least 38% of neonatal deaths in Thailand.

In the Maprik area of the Sepik District, New Guinea, we found that the disease was very common, although it seldom came to the notice of doctors. Women during childbirth and the first one to two weeks of the puerperium are secluded as "unclean" in "menstrual houses" where no man dare visit them. It is thought that if he became "contaminated" by such women his yams, one of the staple crops and an important prestige symbol in the local Abelam people's culture, would fail