STAPHYLOCOCCUS AUREUS

AND

THE NEW-BORN CHILD

BY

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FOREWORD.

This survey of infection of the new-born child by Staphylococcus aureus was carried out over a period of four years and was conducted in a fairly closed community of 95,000 inhabitants.

The control of Staphylococcal disease in the new-born was developed over three main periods and these are discussed in separate sections of the thesis. A further section concerns various other aspects studied over the complete period. This arrangement necessarily entails some slight repetition but it is considered that this method of presentation aids more critical assessment of the problem.

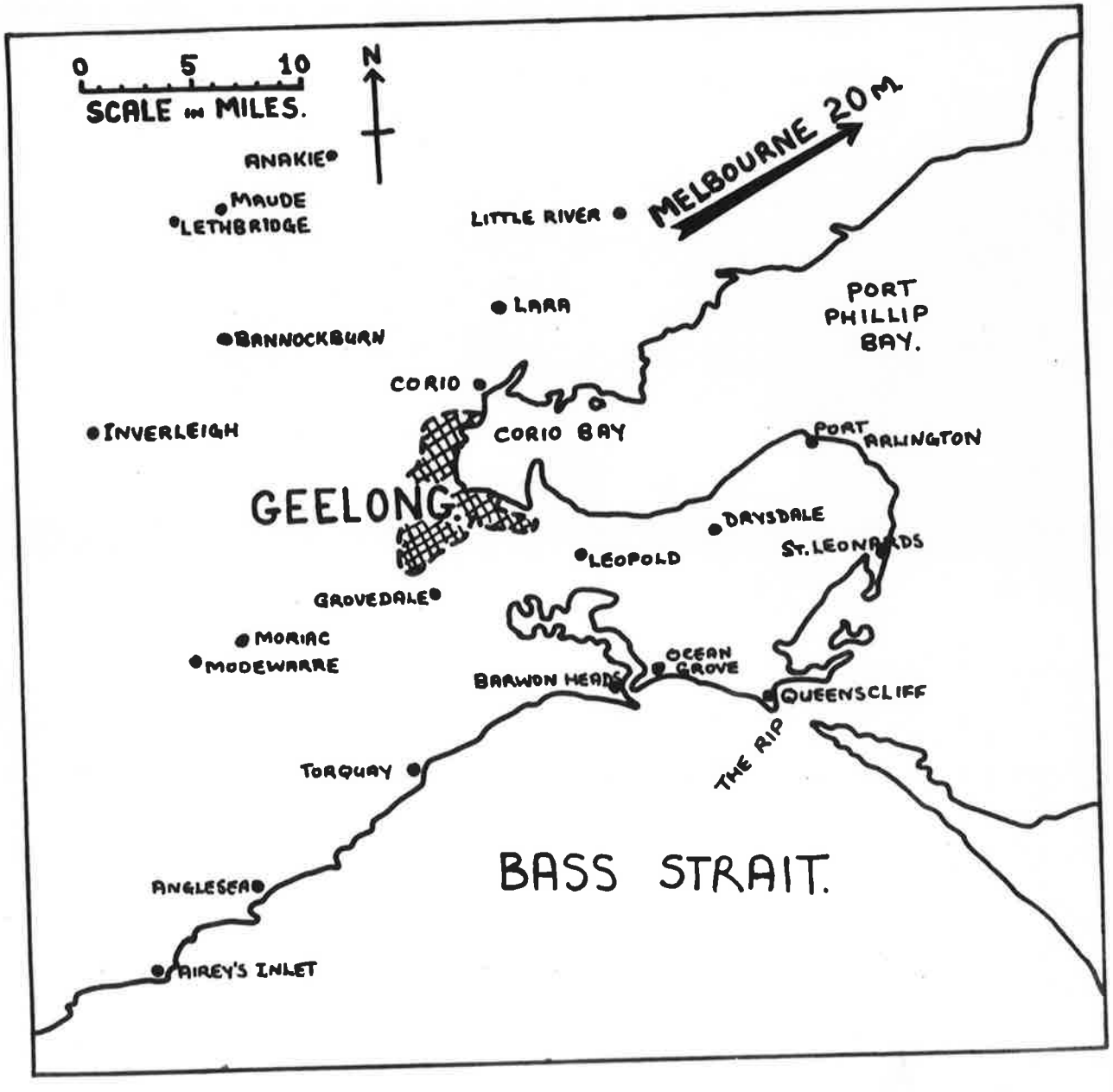

Figure 1. GEELONG and SURROUNDING DISTRICTS

Figure 2. BAXTER HOUSE

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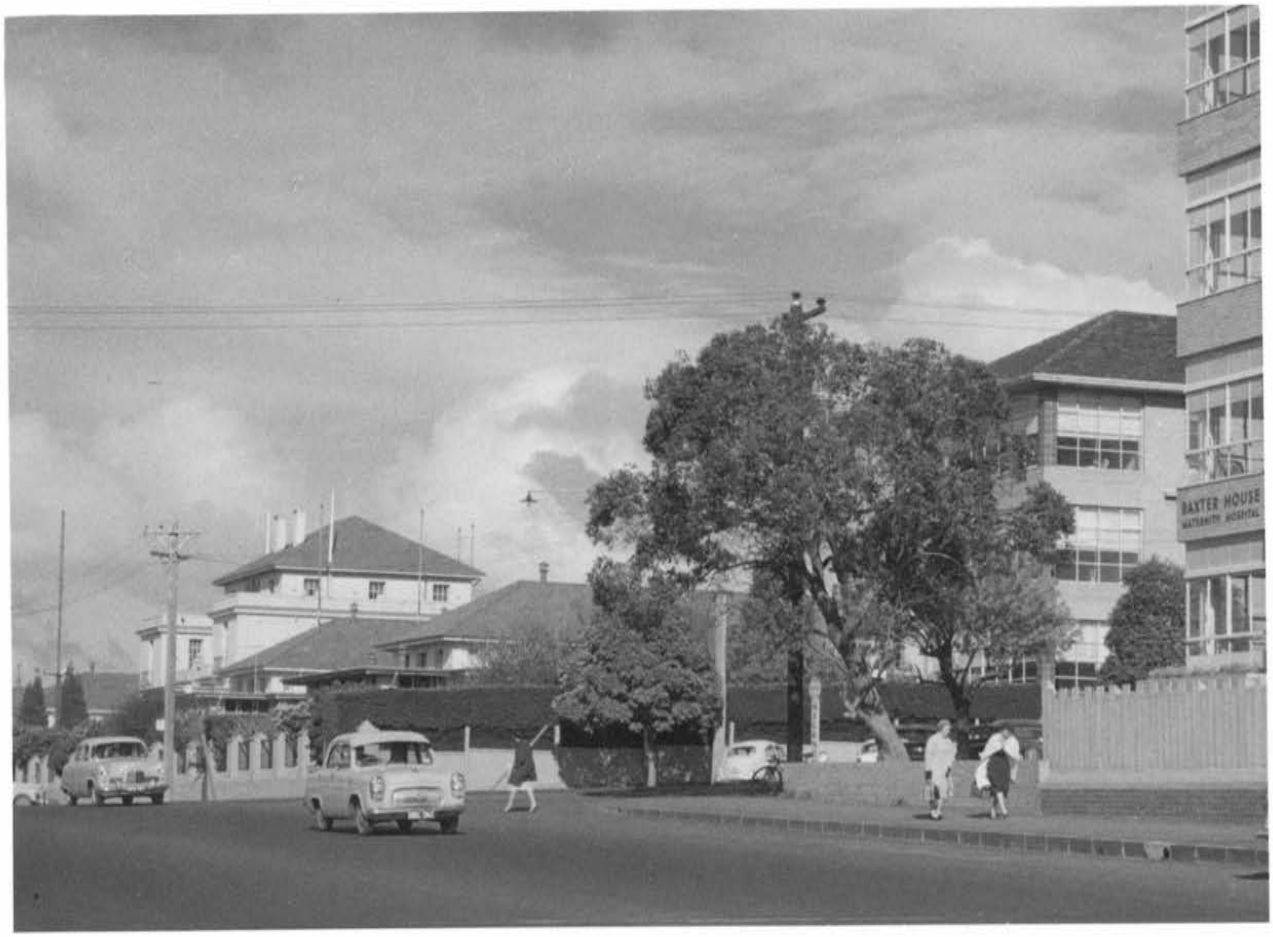

Figure 3. GEELONG and DISTRICT HOSPITAL

I. INTRODUCTION.

"The Staphylococcus aureus is the commonest cause of neonatal infection in maternity hospitals, and it causes a great variety of lesions."

J.L. Henderson, Honyman Lecture, EDINBURGH (1943).

The subject matter of this thesis is taken from a four year survey of staphylococcal infection and staphylococcal disease in newborn infants. The study was prompted in 1956 by the high incidence of skin lesions, conjunctivitis and other minor cases of staphylococcal disease occurring among the babies born in a modern multi-storied maternity hospital.

Geelong & District Hospital is a 438 bed general hospital serving a rural industrial city of 95,000 inhabitants and approximately 60 general practitioners. There are in addition two small private hospitals which undertake some surgery but no obstetrics. All public and private midwifery in Geelong and the surrounding districts for a radius of approximately 25 miles (Figure 1), is performed in Baxter House (Figure 2), which is the maternity wing of the Geelong & District Hospital (Figure 3).

Baxter House has 95 maternity beds in single rooms, two and four bed wards and one eight bed ward. There is a well equipped delivery suite containing eight separate labour rooms and a modern operating theatre. Only obstetrical surgery is performed in the latter. There is a general nursery on each floor and a central premature nursery on the first floor. The general nurseries are similar on all floors and vary from 342 square feet to 432 square feet in area and have in addition a changing and food preparation room attached to each (Figure 4). Infectious cases are nursed on the ground floor in an isolation unit which has its own delivery suite and nursery.

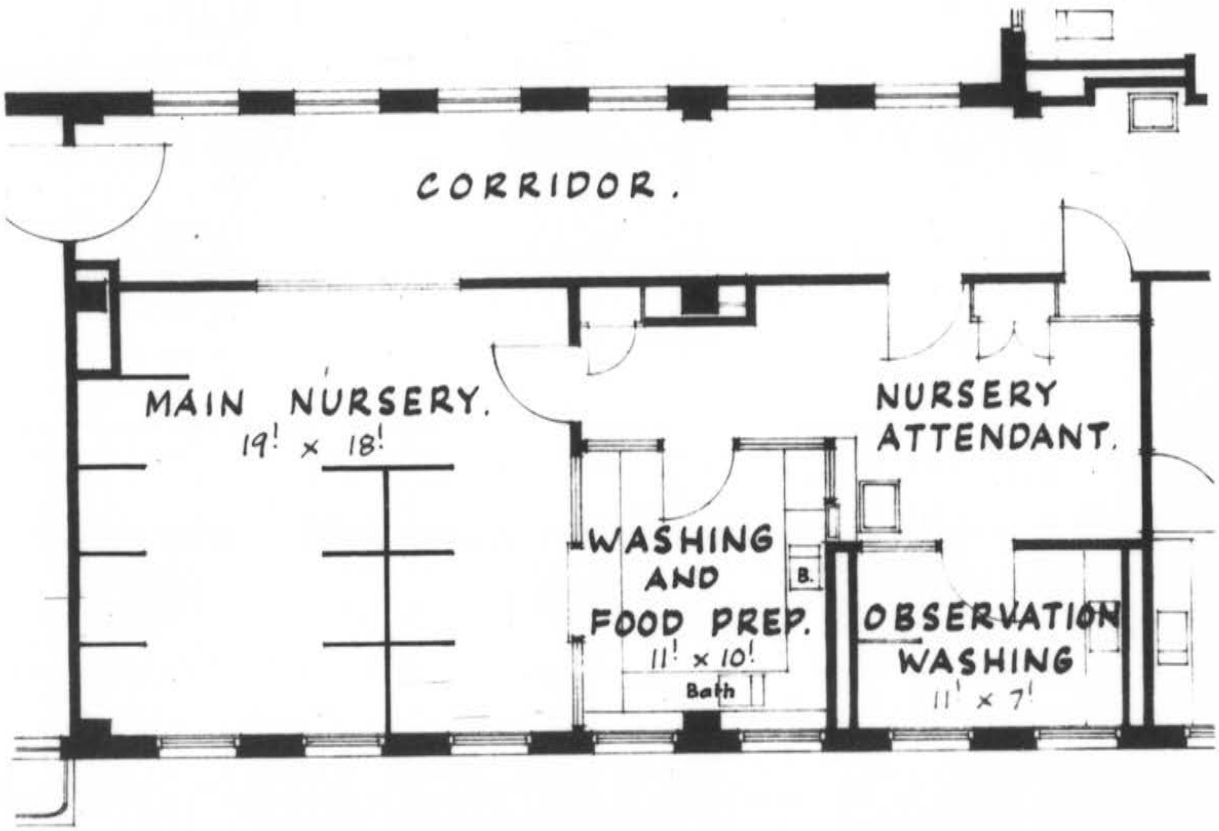

Figure 4. GROUND PLAN OF TYPICAL GENERAL NURSERY

This maternity hospital performs an average of 2,400 deliveries per year of which slightly less than 80% are private patients. The study covered all infants in the first ten days of life in hospital with no distinction between private and public patients. The average period of stay in hospital of each infant was eight days.

This study includes more than 95% of all babies born in the Geelong area during the period July 1st, 1956 - September 30th, 1960. The following two factors were largely responsible for making this completeness possible.

1. The whole hearted support and assistance given by every medical practitioner in Geelong and the surrounding district in supplying information about private patients and giving access to these records.

2. The relatively closed and centralized medical services present in Geelong and its surrounding district.

This survey has been responsible in Geelong and Districts for a better understanding and sensible handling of the problem of staphylococcal infection in the new-born child. It has also formed the basis of methods leading to the control and virtual elimination of staphylococcal disease in the maternity wing of the Geelong & District Hospital and is thus directly responsible for the marked decrease in both the morbidity and mortality of infants. I am of the opinion that these facts and the completeness of the survey and its follow up make the study a definite contribution to the furtherance of medical knowledge.

II. Historical.

> "During the last year a disease has prevailed, to a considerable extent, among the children born in the hospital, which is otherwise a rare occurence, viz. the pemphigus infantilis."
>
> Edward Rigby, General Lying-in Hospital, LONDON (1836).

Much has been written in the past decade about the problem of staphylococcal infection in babies in maternity hospitals in most parts of the world (Barber, Hayhoe & Whitehead 1949, Colbeck 1949, Melin & Wallmark 1949, Rountree & Barbour 1950, Douglas & Knights 1956, Wysham, Mulhern, Navarre, La Veck, Kennan & Giedt 1957a). Reports have also come from most states of Australia - N.S.W. (Rountree & Barbour 1950) - South Australia (McCartney & Yates 1956) - Western Australia (Mathew & Manessis 1956) and Victoria (Plueckhahn & Banks 1958).

The public also have been interested and "the staph" is as much a talking point between nursing mothers as it is between nursing sisters. The daily newspapers also periodically fan interest in the "golden staph" and the general public being fleetingly as concerned about the staphylococcus as they are about nuclear warfare. All these things have increased the belief that the problem of the staphylococcus and the new-born has worsened or only arisen in recent years.

Early writing about the staphylococcus and the new-born child mainly concerns the skin manifestations of staphylococcal disease in babies in the form of pemphigus neonatorum or impetigo neonatorum. Many early reports of skin conditions likely to be staphylococcal in origin are frequently confused by the prevalence of other diseases caused by micro-organisms such as Treponema pallidum and the haemolytic streptococcus. In like manner the part played by the staphylococcus in neo-natal diseases of the eye is also largely clouded by the gonococcus and silver nitrate solution.

The earliest description of pemphigus neonatorum was by Ochene in France in 1773 (Benians & Jones 1929). The first English report of staphylococcal skin disease in the new-born came from the General Lying-in Hospital, London in 1834 and was recorded as follows by Edward Rigby in the London Medical Gazette of 1836, "During the last year a disease has prevailed, to a considerable extent, among the children born in the hospital, which is otherwise of rather rare occurrence, viz. the pemphigus infantilis, appearing on different parts of the body, particularly the extremities and neck, in minute vesicles, which gradually increase in bullae, and which burst, leaving a raw discharging surface: the ichorous fluid which is secreted innoculates the surrounding parts and this keeps up the disease for some time. Generally speaking, the children have recovered from it, but in two or three it has spread to a great extent and produced such constitutional irritation as proved fatal." Dr. Rigby asked Mr. D. Dalrymple to draw up a report on "Mrs. Martyn's child" who was a particularly severe and fatal case and whose mother suffered severely from inflamed nipples. The report by Mr. Dalrymple was concluded as follows, "This disease was not confined to the children only, but some of the mothers had many spots, Mrs. Martyn in particular, and in a few days after the post-mortem examination, during which I pricked myself, several spots made their appearance on my face and chest, which were some days before they healed and to the pain and irritation which they excited I can testify."

There were scattered reports in the French and German literature between the years 1850 and 1880. Lasegue & Trousseaux (1850) describe an epidemic of "Varicelle Pemphigoid" which Brocq (1902) considered was without question, an epidemic of pemphigus neonatorum. Moldenhauer (1874) reported 94 cases of pemphigus neonatorum occurring in an outbreak at the Leipsic Obstetrical Clinic in 1872-1873.

A very complete description of epidemics of a skin disease occurring in a foundling hospital in Prague, between the years 1868 and 1878 was given by Ritter von Rittershain in 1878. In this year there were 297 cases affecting babies in the first or second week of life.

The condition was characterised by a redness commencing around the mouth and rapidly spreading over the entire body or portions of it. With the redness was oedema of the skin and exfoliation of the superficial epidermal layer leaving a dark red dry or moist surface beneath. There were in addition vesicles, bullae and pustules of the intact skin. The condition lasted seven to ten days and was fatal in 48% of the cases and was named dermatitis exfoliativa neonatorum by Ritter. Many similar epidemics have been described and reported since and some dermatologists still consider the condition as a distinct entity. I am convinced by a study of the literature that the condition is a special variety of pemphigus neonatorum and like Richter (1901), Cole & Ruh (1914) and Allen (1954), consider Ritter's disease as one of the manifestations of staphylococcal disease in the new-born.

Impetigo contagiosa was carefully studied by Tilbury Fox (1864a & b) in England and he described pustules and vesicles of typical staphylococcal skin disease in various reports of the condition. Tilbury Fox extensively studied the condition but did not mention lying-in hospitals although he did say that the eruption was first characterised by ".... its occurence chiefly in the child."

Demme (1886) first reported the isolation of an organism from the lesions of pemphigus neonatorum when he grew a non-chromogenic diplococcus. Five year later Almquist (1891) studied an epidemic of pemphigus neonatorum in the Maternity Hospital at Gottenborg where 134 of 216 children born were affected and of these four died. Efforts made to isolate those babies affected and to disinfect the hospital were of no avail and the outbreak lasted six months. Almquist regularly isolated a diplococcus which he named Micrococcus pemphigi neonatorum from the fluid in vesicles on affected babies and although this organism closely resembled Staphylococcus aureus on culture, he considered it to be different as it produced on human inoculation experiments, a more superficial lesion than those resulting from organisms isolated from a carbuncle.

The medical literature just before and after the turn of the century contains much discussion about Pemphigus neonatorum and Impetigo contagiosa and showed a slow evolution of opinion considering the cause as similar or the same. Faber (18900) considered the two conditions identical and that the varying clinical picture was due to the difference in age groups. Matzenauer (1900) studied both conditions and considered them identical and was also of the opinion that the organisms responsible were indistinguishable from Staphylococcus pyogenes aureus. This opinion was not uniformly held and others such as Almquist (1891) thought that the causative organisms showed slight differences when carefully studied.

Clegg & Wherry (1906) reported that in 1904 almost every child born in the maternity ward of the Civil Hospital at Manila in the Phillipine Islands, contracted pemphigus neonatorum during the period of convalescence of the mother. These authors by careful bacteriological study of five cases, isolated an organism identical to that described by Almquist and which they considered distinctive from Staphylococcus pyogenes aureus on culture, despite its similarity. Clegg & Wherry also isolated an organism identical to that isolated from the babies in a case of pemphigus contagiosus in an adult and they considered both conditions identical and named the causative organisms, Micrococcus pemphigi contagiosis!

Foerster (1909) described a benign and malignant form of phemigus neonatorum and of the former said that few lesions developed, constitutional symptoms were entirely absent, and rapid healing occurred. Even at this period the aetiology of pemphigus neonatorum was still confused and Foerster stated that it could "be produced by either the common staphylococci or streptococci-most often by the former."

Four of the six dermatologists taking part in a discussion on Foerster's paper were more convinced that the streptococcus was the usual cause of pemphigus neonatorum and impetigo contagiosa. Most of these opinions were largely influenced by and based on the investigations and statements of Sabouraud (1900) some nine years previously.

Cole & Ruh (1914) described an outbreak of nine cases of pemphigus neonatorum in Cleveland and from each case isolated a pure growth of Staphylococcus aureus on culture and also found numerous groups of agglutinated Gram positive cocci in the veins of the lungs and liver of one fatal case. Despite this evidence they stated "Only very careful observations and extensive cultural examinations will enable us to strictly rule out the possible existance of a pemphigus neonatorum due to the streptococcus."

Falls (1917) dispelled any lingering doubts concerning the aetiology of pemphigus neonatorum by a very complete bacteriological investigation of an epidemic of 69 cases with two deaths which occurred in Chicago in 1915 and 1916. He showed conclusively that the disease was caused by Staphylococcus aureus which under certain conditions of growth appeared as the diplococcus described by earlier writers. Falls in summary said - "Pemphigus neonatorum is a peculiar type of staphylococcic dermatitis occurring in the new-born, but capable of transmission to adults. The causative organism is a strain of Staphylococcus aureus, indistinguishable culturally and biologically from some other strains of staphylococcus but differing under certain circumstances morphologically, and showing different pathogenic tendencies."

With the development of bacteriology as a more exact science, other ways in which Staphylococcus aureus played a part in the mortality and morbidity of new-born infants became apparent. Browne (1922) found at the Royal Maternity Hospital, Edinburgh, that pneumonia was responsible for 21 of 80 deaths in infants during the first week after birth and stated that "Acute haemorrhagic pneumonia of infants forms a distinct clinical and pathological entity which gives rise to sudden death in children who may be apparently previously healthy, either full-time or premature." Browne isolated Staphylococcus aureus from one of the three cases in which cultures were made. It was in Edinburgh some twenty years later that Agnes McGregor (1943) again emphasized the importance of primary pneumonia in neonatal deaths and stressed the part

played by the staphylococcus. She said "One fact about infection in the new-born needs to be stressed. Newly born infants are highly susceptible to infection by common organisms, even by some that are not usually regarded as highly pathogenic. As a first example may be cited the case of staphylococcal infections. Staphylococcus aureus always has the potentialities of a dangerous pathogen, but is not familiar as the sole cause of a form of primary pneumonia. When it plays a part in the case of pneumonia in an older person it is usually as a concominant or complicating factor in an infection that is primarily due to another cause, for example, influenze. In infancy, and especially in the neonatal period, primary staphylococcal pneumonia, without any accompanying or antecedent infection, is far from uncommon." This statement was followed by a classical description of primary staphylococcal pneumonia. Henderson (1943) quoted a 100% mortality of the 11 cases of primary pneumonia occurring in 8075 infants. From then on numerous reports occurred in the literature (De Pape &McEwan 1951, Kanof, Epstein, Kramer & Mauss 1954, Taft 1955, Beaven & Burry 1956, Briggs 1957).

In Edinburgh in 1943, Henderson gave the first complete picture of the ubiquity of the staphylococcus in Maternity Hospitals and its wide association with infection in the new-born. His account is almost identical with the numerous recent reports from maternity hospitals all over the world. Henderson in clarifying the position of the causes of infective conjunctivitis in 1140 infants said, "The most striking points in the table are the overwhelming predominance of Staphylococcus aureus conjunctivitis over all other types." The complete review showed that there were 1185 cases of staphylococcal disease during the stay in hospital of the 8075 infants born in the three year period 1940 - 42. The cases included 624 of conjunctivitis, 550 of staphylococcal skin infection and 11 of primary staphylococcal pneumonia. This last group was the only one in which deaths occurred.

The endemic nature of the staphylococcal disease in the new-born was fully appreciated by Benians (1943) who followed an outbreak

of "bullous impetigo neonatorum" in the North Middlesex County Hospital and said that in the following 12 months a mild papular type of infection continued to occur in five to fifteen per cent of all infants born. Benians stressed that the presence of Staphylococcus aureus in babies was not synonymous with staphylococcal disease and found the "carrier condition" widespread, especially in the winter months when 30% of the women admitted to labour and nearly 100% of babies ten days old in the nurseries were carriers of Staphylococcus aureus.

Benians (1943) also cultured the milk of nine mothers and found Staphylococcus aureus in seven. The only infant of the nine mothers to develop impetigo was from one of the two mothers whose milk remained negative throughout the investigation. At about the same time Duncan & Walker (1942) showed that staphylococci could readily be transmitted from the throats of infected infants through apparently normal nipples to the milk in the lactiferous ducts of their mothers. The significance of this transmission from child to mother has been studied in later work concerning the aetiology of puerperal mastitis (Colbeck 1949, Wysham, Mulhern, Navarre, La Veck, Kennan & Giedt 1957b, and Monro & Markham 1958).

The first report of Staphylococcus aureus occurring harmlessly in the nose of the new-born was by Bloomfield (1922) who said, "These organisms were found in a few cultures." He does however report "white staphylococci were present in over half of the cultures but were not a consistent finding; they varied in number in various cultures from a few to innumerable colonies. Many types, both haemolytic and non-haemolytic were encountered." The "carrier state" in the nose is now known to be much more frequent with reports of S. aureus being recovered from the nose of up to 50% of babies less than two days old and from almost 100% by the first week of life (Kneeland 1930, Elliot 1942, Cuncliffe 1949, Pleuckhahn & Banks 1958). Swabbings of babies from various sites on the second day of life by Gillespie, Simpson and Tozer (1958) showed Staphylococcus aureus present as follows:-

umbilicus 59% of cases, groin 55%, nose 44%, and neck 27% of cases.

Fairchild (1958) in 2479 cord cultures showed that 80% of umbilical stumps carried Staphylococcus aureus by the fourth day of life. Despite the frequency of umbilical carriage of staphylococci, primary staphylococcal peritonitis is rare. Ryan (1953) reported only one case occurring at the Edinburgh Royal Infirmary between the years of 1929 and 1953. Beaven (1958) reported five cases in Christchurch, N.Z., between the years 1950 and 1955. It is difficult to say whether this later report means an increase in incidence or more awareness of the condition - even if there is an increase in incidence, primary staphylococcal peritonitis is still a rare occurrence.

Many early authors and some present writers consider that neonatal outbreaks of staphylococcal disease are due to special strains of staphylococci and that in fact an "impetigococcus" may exist (Almquist 1891, Clegg & Wherry 1906, Falls 1917, Simpson 1941, and Elek 1959). Serological typing by Andersen (1943) in Norway gave hopeful evidence of a distinct type of staphylococcus causing pemphigus neonatorum. Although Andersen said she could demonstrate the carriers of the pemphigus staphylococcus among hospital personnel, subsequent workers were not as successful.

Serological typing fell into disuse with the introduction of phage typing which appeared to be an answer in investigating the epidemiology of staphylococcal disease in the new-born (Spittlehouse 1955, Gillespie, Pope & Simpson 1957, and Monro & Markham 1958). Strains with apparent marked ability to cause skin lesions were observed in Australia by Isbister, Durie, Rountree & Freeman (1954). In the following year Rountree & Freeman (1955) reported on the isolation of the new phage type 80 which was the causative organism in 19 of the 24 outbreaks of neonatal staphylococcal infection studied by them in hospitals throughout Australia. Since this report, phage type 80 or its closely allied variants has been described as the common epidemic strain in maternity units from all parts of the world - in New Zealand (Douglas & Knights 1956), in the United States of America (Ravenholt, Wright &

Mulhern 1957) and in England (Timbury, Wilson, Hutchison & Govan 1958). Other workers showed that Phage type 80 is not peculiar to the new-born and is just as common in general staphylococcal infections and in outbreaks in surgical units (Hennessey & Miles 1958, Williams 1959, Williams, Talbot & Maughan 1959, National Health and Medical Research Council Special Report 1960).

In the past twenty years much investigation has centred about methods of controlling the spread of staphylococcal disease in maternity hospitals. The community nursery has fallen into some disrepute and opinion has slowly evolved that it is probably better to nurse the mother and baby together as a single unit in the same room or ward (Henderson 1943, Medical Research Council Memorandum No. 11, 1951, and Barber, Wilson, Rippon & Williams 1953). The part played by the staff, particularly as nasal carriers, has been extensively studied (Parker & Kennedy 1949, Miller 1950, Rountree & Barbour 1951, and Rountree, Heseltine, Rheuben, and Shearman 1956). The infant and its surroundings such as the hospital blankets, scales, napkins and dust of the nursery and ward also have been investigated (Medical Research Council 1951, Marsh & Rodway 1954, Edmunds, Elias-Jones, Forfar & Balf 1955, National Health and Medical Research Council 1956, and Timbury, Wilson, Hutchison & Govan 1958).

Other workers have focussed their attention on the baby itself in attempts to lower its carrier rate of the staphylococcus and in turn the incidence of staphylococcal disease. The three main sites concerned in these attempts have been the umbilical cord (Jellard 1957), the nose (Coventry & Isbister 1951), and the skin of the baby (Hardyment 1954).

The use of antibacterial substances such as hexachlorophene or chlorhexidine has yielded very encouraging results in reducing the incidence of staphylococcal skin disease in the baby (Gillespie, Simpson and Tozer 1958, Hill, Butler and Laver 1959, Simpson, Tozer and Gillespie 1960).

The frequency, with relatively low mortality, of staphylococcal infections in the new-born is now firmly established. There still remains the problem of the complete ubiquitousness of the staphylococcus

and there are many questions which still have to be answered about its methods of transmission and means of attack in humans. The work of Ridley (1959) on the perineal carriage of Staphylococcus aureus opens up another avenue of investigation with the possibility of "Pemphigus infantilis" eventually being considered a gastro-intestinal disease.

III. BACTERIOLOGICAL METHODS.

Any reference to the staphylococcus in this thesis, refers to a coagulase positive Staphylococcus aureus unless otherwise stated.

1. Method of Swabbing.

All swabbings were taken with cotton wool swabs moistened in peptone water.

(a) Nasal samples were taken through both nostrils.

(b) Skin samples were taken by rubbing a swab over the back of each hand and then into several inter-digital spaces.

(c) Umbilical samples were obtained by rubbing the swabs in and around the umbilical stump.

(d) A separate conjunctival swab was taken from each eye.

(e) Rectal and vaginal swabs were taken with suitable aseptic technique.

(f) Samples from scales, door handles and other inert areas were taken by vigorous rubbing of these areas with a moist swab.

2. Cultures.

(a) 1956 - 1959.

All swabs taken were plated on horse blood agar and read after overnight incubation at 37°C. If the staphylococcus was isolated, the amount of growth was recorded as follows:-
The number of colonies if less than 10 colonies;
+ (one plus) if 10-50 colonies;
++ (two plus) if 50-150 colonies;
+++ (three plus) if heavy growth of separate colonies over the whole plate;
++++ (four plus) if a confluent growth.

In addition every swab was innoculated into nutrient broth which after incubation for 24 hours, was plated on to blood agar. Since January 1959, "salty broth" (nutrient broth with added 6% (W/V) Na Cl) has been used instead of

simple nutrient broth. All swabs which yielded a coagulase positive Staphylococcus aureus were counted as positive. Included were those swabs yielding small numbers of staphylococci revealed by the nutrient broth or "salty" broth culture.

(b) 1960.

Following the introduction of hexachlorophene emulsion all swabs were in addition plated on to a nutrient agar plate containing 1% (V/V) polysorbate 80. (Smylie, Webster & Bruce 1959).

3. Coagulase Activity.

All Gram positive cocci isolated, other than streptococci, were examined for coagulase reaction firstly by the slide technique using human plasma (Cadness-Graves, Williams, Harper & Miles 1943). If this was negative the strain was further tested by the tube technique using 1:10 human plasma.

4. Anti-biotic Sensitivity.

All strains of staphylococci isolated were tested for anti-biotic sensitivity by using Evans "sentest" discs. The following is a list of the strength and substances used:-

Penicillin	0.5 I.U.
Streptomycin	20 micrograms
Chloramphenicol	40 micrograms
Tetracycline	10 micrograms
Erythromycin	1 microgram

In 1958, 1959 and 1960 some staphylococci were in addition tested against:

Novobiocin Na	2 micrograms
Sulphafurazole	0.1 milligramme

In the 1956 and 1957 surveys many staphylococci were also tested against:

Oxytetracycline HCl	10 micrograms
Chlor-tetracycline	10 micrograms

5. PHAGE TYPING.

Many 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 stock phages were tested in 1959 against a set of staphylococci from the Staphylococcus Reference Laboratory, Colindale, London and no significant departures from the expected typing results of these strains were found. The majority of the phage typing was performed by Dr. Hildred Butler of the Royal Women's Hospital, Melbourne.

6. RECORDING OF INCIDENCE OF STAPHYLOCOCCAL DISEASE IN BABIES.

All babies were examined daily over a period of 10 days in October and November 1956, and March and April 1957. As from April 1957 all babies were examined daily by the respective floor sisters or a selected member of my staff. A swab was taken from any area showing the slightest evidence of clinical infection - this included reddened umbilical stumps, slightly "sticky" eyes and minor rashes. Any infant with a lesion from which a staphylococcus was isolated was recorded as having staphylococcal disease.

This system was uniformly used throughout the entire survey and probably resulted in a higher recording of staphylococcal disease than was actually the case, as the presence of the staphylococcus in some lesions may well have been incidental and not the cause. Nevertheless it was considered that any method of selection was not justified and in fact was impossible, for minor lesions yielded confluent growths of staphylococci and a severely inflamed eye or extensive pustular lesion occasionally gave a negative culture.

IV. 1956 AND 1957.

> "Practically every child born in the maternity ward of the hospital contracts the disease during the period of the mother's convalescence."
>
> Clegg & Wherry, MANILA (1906).

1. INCIDENCE OF STAPHYLOCOCCAL DISEASE IN NEW-BORN.

All babies born were examined daily over a period of 10 days in October and November 1956, and again in March and April 1957. Swabs were taken from any lesion found on the 380 babies under the age of 10 days examined. 182 different lesions from 156 babies grew a coagulase positive Staphylococcus aureus, that is 41.0% of the babies born during this period showed clinical evidence of staphylococcal infection in the first 10 days of life.

The sites and types of lesions growing staphylococci and the incidence per cent of all babies examined showing the particular lesion are as follows:-

Sticky eyes	54 (14.2%)
Infected umbilicus	58 (15.3%)
Skin lesions	46 (12.1%)
Nasal infection	11 (2.9%)
Paronychia	13 (3.4%)

2. "CARRIER RATE" OF STAPHYLOCOCCUS.

(a) Babies.

On two days in May and September 1957, swabs were taken from both eyes, the nose and the umbilicus of all normal babies up to 10 days old. 460 swabs were taken from the 115 babies and a coagulase positive Staphylococcus aureus was isolated on culture from 251 of these swabs.

99 babies yielded staphylococci from at least one site.

21 babies yielded staphylococci from all four sites.

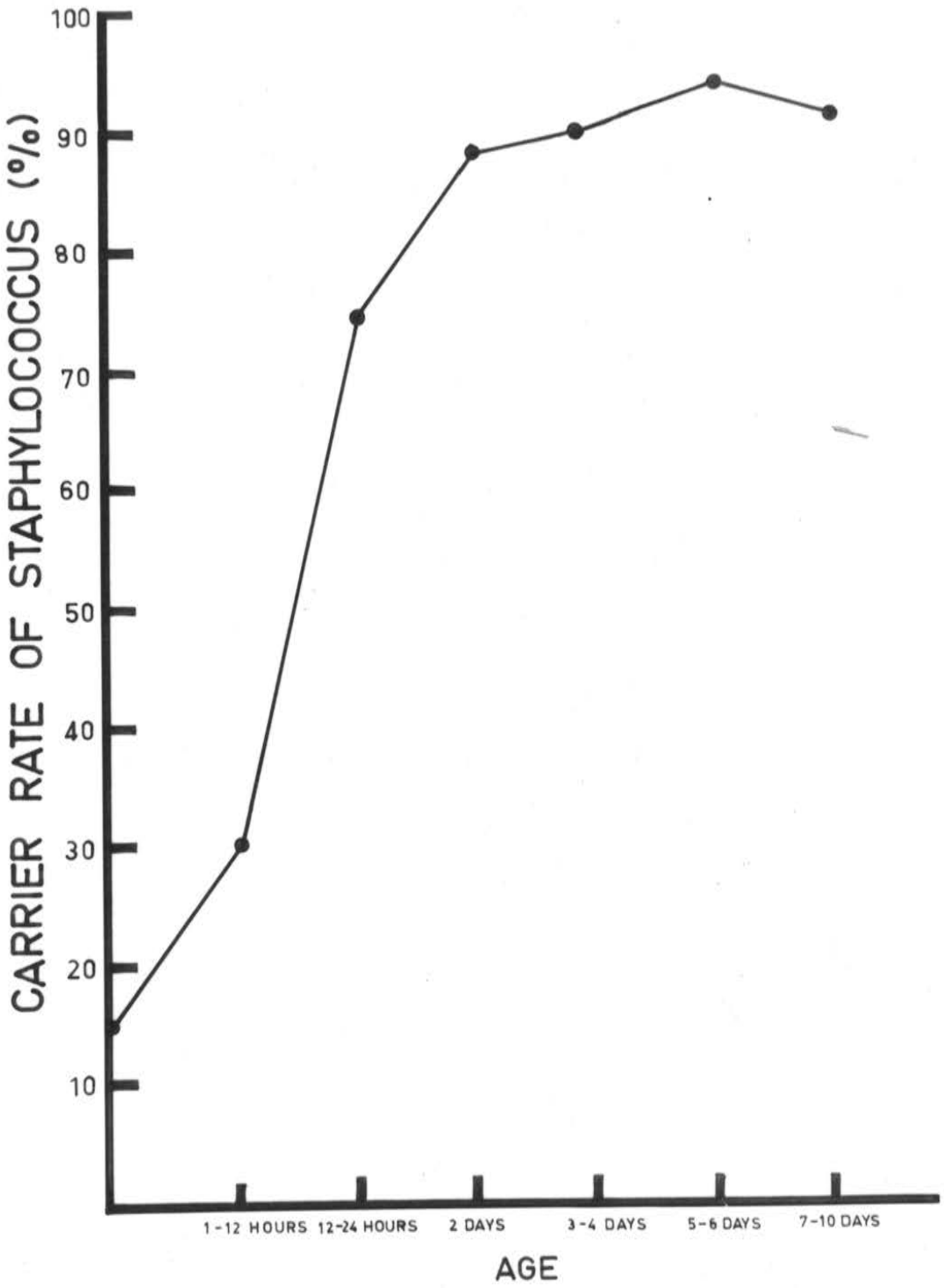

FIG 5 INFANT CARRIER RATE 1957.

The ages of the 115 babies examined are compared with the presence or otherwise of Staphylococcus aureus in Table I. The infant "carrier rate" is shown graphically in Figure 5.

TABLE I. INFANT "CARRIER RATE" 1957.

AGE OF BABY	NUMBER OF BABIES	S. AUREUS GROWN	SITE OF POSITIVE SWABS		
			EYES	UMBILICUS	NOSE
0–12 hrs	3	0	0	0	0
12–24 hrs	3	1	0	1	1
2 days	13	8	4	6	5
3– 4 days	22	19	11	17	12
5– 6 days	38	38	28	28	33
7–10 days	36	33	22	25	26
TOTAL	115	99	65	77	77

(b) MOTHERS AND STAFF.

Concurrently with the above survey the hands and noses of 130 members of the nursing staff were swabbed.

S. aureus was isolated from the nose of 88 (68%)

S. aureus was isolated from the hands of 36 (28%)

70 of the above group had throat swabs taken as well. Of these only three yielded staphylococci.

118 mothers had swabs taken from their hands and noses.

S. aureus was isolated from the nose of 62 (53%)

S. aureus was isolated from the hands of 14 (12%)

(c) ENVIRONMENTS.

Miscellaneous areas on all floors and the basement of Baxter House were swabbed in November 1956, and again in May 1957 by when certain reforms in nursing technique had taken place and there were fewer positive cultures. Despite this the results of both months have been grouped together in Table II, as the areas concerned were just as varied.

TABLE II. MISCELLANEOUS AREAS GROWING STAPHYLOCOCCI 1956 & 1957.

SITE OF CULTURE	SWABS TAKEN	S. AUREUS GROWN
Delivery Rooms		
Infant "suckers"	5	2
Cord ties	4	1
Wash basin ledge	5	2
Floor	3	-
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 bin	7	1
Various "spirit" and oil bottles	24	9
Various ointment tubes	10	2
Door handles	7	2
Window ledge	4	2
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	15	2
Lavatories - Door handles	12	-
Telephone	1	1
Laundry		
Bags and bins on various floors	10	2
Bulk laundry-"Dirty"	11	6
Bulk laundry-"Clean"	8	-
TOTAL	256	85 (33%)

3. SUMMARY.

"Outside show is a poor substitute for inner worth".
Aesop (570 B.C.)

The life of the babies was very busy in 1956 and involved repeated handling by various staff. At each bottle the baby was handled by several people and then weighed on scales from 50% of which, staphylococci could be grown. In addition, the infant was completely undressed once a day and fully bathed in baths from which profuse growths of staphylococci could be grown in five of the eleven swabbed (Table II). It was routine practice for most eyes to be wiped with moist swabs at intervals and then to have one of a variety of antibiotic or antiseptic drops or ointments instilled. Between these procedures the babies slept in attractively painted community nurseries in which the air was kept moving by the coming and going of nursing and medical staff, by cribs being made, babies being changed and "dirty" linen sorted. In many cases wash-basins were separated from the nurseries by doors which required opening by handles. All these things greatly increased the ease of transmission of the staphylococcus.

An assessment of the amount of movement by staff was obtained by giving mothers automatic counters on which to record each visit by a member of the hospital staff. This included staff bringing the baby in and out of the room, bed pans, dressings, meal trays, flowers, letters and the other numerous interruptions often complained of by "tired" mothers (Table III). The third column represents the average number of visits per day for each individual mother. Personal visitors of the patient are not included.

TABLE III. MOVEMENT BY HOSPITAL STAFF

DAYS AFTER DELIVERY	NUMBER OF MOTHERS	AVERAGE VISITS PER DAY
First	6	139
Second	6	115
Third	2	70
Fourth	3	61
Fifth	3	56
Sixth	2	51

The following three principal facts were shown by the survey:-

(a) The ubiquitousness of the staphylococcus.

(i) 100% "carrier rate" on babies by 5th day of life.

(ii) 68% of the staff and 53% of the mothers carried staphylococci in their noses.

(iii) 33% of the 256 non-living articles tested harboured the staphylococcus.

(b) The constant handling of the new-born baby by numerous different staff.

(c) The gross amount of staff traffic in a large maternity hospital.

The above facts lead to the following deductions concerning the conduct of Baxter House.

(a) The observation of the nursing staff of first principles in handling potentially infected material and the understanding of cross-infection was very poor.

(b) Daily bathing and oiling of babies was a potential source of cross infection.

(c) Frequent weighing of babies did not appear to serve any useful purpose and was a further means of transmission of the staphylococcus.

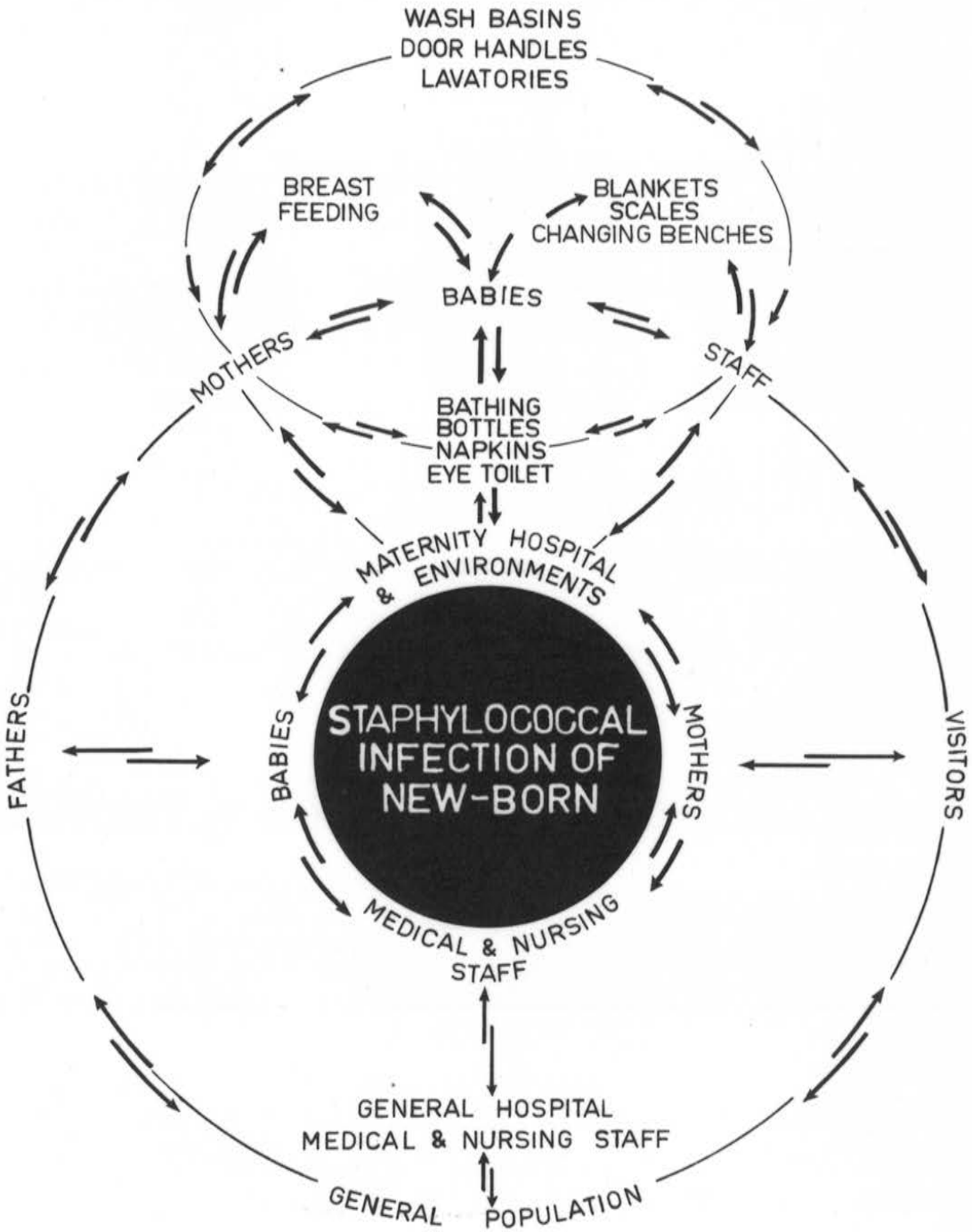

FIG. 6 MODES OF TRANSMISSION OF THE STAPHYLOCOCCUS

(d) Direct contact between staff, babies and mothers appeared to play the major role in the spread of the staphylococcus. Droplet infection from staff did not appear to be a potent source as only 4% carried the organism in their throat. Hare & Thomas (1956) agree that egress from the mouth is an unimportant factor in the dissemination of Staphylococcus aureus.

(e) Transfer of infection by the hands of staff was accentuated by:

(i) Poor positioning of wash basins - many were separated from area of use by doors.

(ii) Use of community towels.

(f) The movement and contamination of air was increased by the changing of bed clothes and sorting of dirty linen in nurseries.

Each of the above could aid and accentuate cross-infection and was thus a potential source of staphylococcal disease in the new-born (Figure 6).

In view of the facts supplied by these surveys the following general changes in the conduct of Baxter House were recommended.

(a) All nursing staff to have regular and well prepared lectures and demonstrations concerning first principles of aseptic technique and the control of cross-infection.

(b) Daily bathing of babies to stop. To be replaced by a bath in sterile water 3-8 hours after birth. A further demonstration bath on day of discharge could be given to babies of primiparas. Eyes only to be wiped if ordered by the medical officer in charge.

(c) Weighing of babies to cease unless medically indicated. Babies to be weighed on sterile paper on scale pan. This paper could be newspaper and must be discarded immediately after use.

(d) Any member of the staff with clinical staphylococcal infection

Figure 7.(left)
ROOMING-IN COT

Figure 8.(below)
ROOMING-IN

to be excluded from the maternity wing until he or she was bacteriologically clear of the infection.

(e) Hand washing facilities to be reviewed and the following changes recommended.

(i) Re-positioning of wash basins where indicated.

(ii) Hexachlorophene antiseptic soap to be used for hand washing.

(iii) Community towels to be replaced by paper towels or individual disposable towels.

(iv) "Hibitane" hand cream to be used on hands after drying.

(v) Doors to be removed where possible.

(f) Standardization and control in handling of "dirty" and clean linen. No linen to be sorted in nurseries or wards.

(g) The adoption of "Rooming In". That is the nursing of the baby in a specially constructed self-contained cot (Figure 7) next to the bed of its mother (Figure 8). All handling of the baby to be done by the mother.

The hospital authorities agreed to immediately implement all recommendations other than (g) which was delayed pending the purchase of suitable cots and education of the nursing staff and mothers in the principles of "Rooming In".

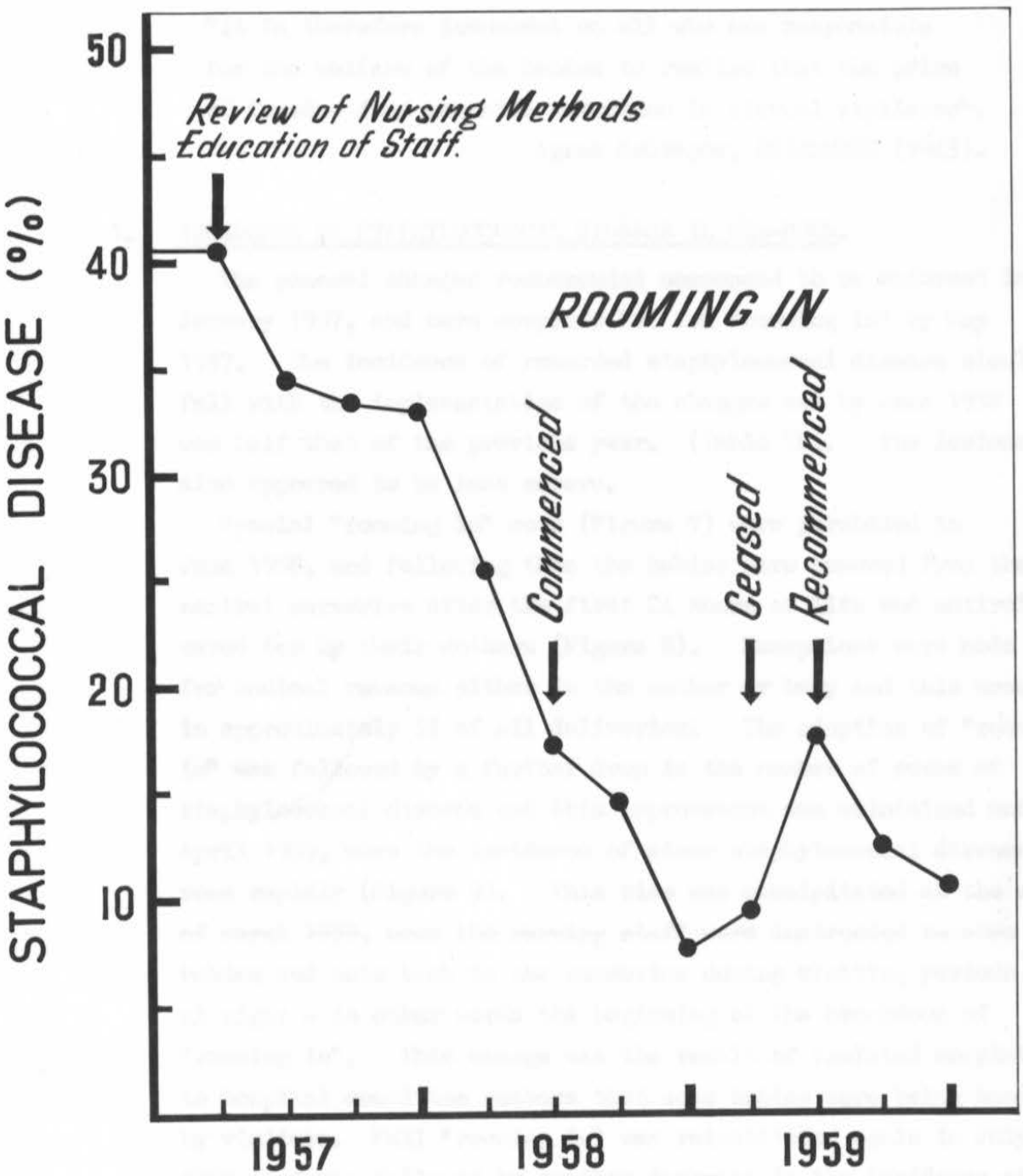

FIG. 9 INCIDENCE OF RECORDED STAPHYLOCOCCAL DISEASE IN NEW-BORN

V. 1957, 1958 & 1959.

"It is therefore incumbent on all who are responsible for the welfare of the babies to realize that the price of freedom from neonatal infection is eternal vigilance".

Agnes McGregor, EDINBURGH (1943).

1. INCIDENCE OF STAPHYLOCCOCCAL DISEASE IN NEW-BORN.

The general changes recommended commenced to be enforced in January 1957, and were complete but for "rooming in" by May 1957. The incidence of recorded staphylococcal disease slowly fell with the implementation of the changes and by June 1958 was half that of the previous year. (Table IV). The lesions also appeared to be less severe.

Special "rooming in" cots (Figure 7) were purchased in June 1958, and following this the babies were removed from the central nurseries after the first 24 hours of life and entirely cared for by their mothers (Figure 8). Exceptions were made for medical reasons either in the mother or baby and this occurred in approximately 5% of all deliveries. The adoption of "rooming in" was followed by a further drop in the number of cases of staphylococcal disease and this improvement was maintained until April 1959, when the incidence of minor staphylococcal disease rose rapidly (Figure 9). This rise was precipitated at the end of March 1959, when the nursing staff were instructed to move the babies and cots back to the nurseries during visiting periods and at night - in other words the beginning of the breakdown of "rooming in". This change was the result of isolated complaints to hospital committee members that some babies were being handled by visitors. Full "rooming in" was reinstituted again in July 1959, and was followed by another decrease in the incidence of staphylococcal disease in the new-born (Figure 9).

TABLE IV. INCIDENCE OF RECORDED STAPHYLOCOCCAL DISEASE IN NEW-BORN.

(The table gives the average per cent of babies showing staphylococcal disease in each three month period).

TIME	BABIES BORN	INFECTED BABIES
1957		
April - June	557	34.7%
July - September	616	33.6%
October - December	654	33.0%
1958		
January - March	609	25.6%
April - June	508	17.1%
July - September	591	14.7%
October - December	615	7.9%
1959		
January - March	594	9.1%
April - June	559	17.9%
July - September	607	12.4%
October - December	633	10.6%
TOTAL	6543	19.7%

2. "CARRIER RATE" OF STAPHYLOCOCCUS AUREUS - 1959.

"The chief difficulty concerning the micrococci is, that they are often found in a form that does not readily cause inflammation".

Sir Alexander Ogston, ABERDEEN (1882).

(a) BABIES.

On two days in May and October 1959, swabs were taken from both eyes, the nose and umbilicus of normal babies up

to 10 days old. A limited but not selected number of these babies were followed to their homes and swabbed during the first, second, third and fourth weeks after discharge from hospital (Table V).

TABLE V. INFANT "CARRIER RATE" - 1959.

AGE OF BABY	NUMBER OF BABIES	S. AUREUS GROWN	SITE OF POSITIVE SWABS		
			EYES	UMBILICUS	NOSE
At birth	20	3	2	1	2
1-24 hrs	21	11	1	10	2
2 days	25	22	9	16	4
3- 4 days	50	45	22	34	23
5- 6 days	50	47	28	32	26
7-10 days	55	51	26	36	35
14 days	18	15	10	12	14
21 days	19	14	12	7	10
28 days	18	13	13	8	11
35 days	19	13	11	10	10

(b) MOTHERS, NURSING STAFF AND "NORMAL WOMEN".

At the same time as the babies were swabbed, nasal and hand swabs were taken from the mothers and nursing staff. Similar swabs were taken from one hundred consecutive ambulant women attending the Pathology Department for tests other than bacteriological tests. None of these women were in-patients or out-patients of the Geelong & District Hospital.

TABLE VI. "CARRIER RATE" OF MOTHERS, NURSING STAFF AND "NORMAL WOMEN" - 1959.

	NUMBER SWABBED	S. AUREUS FROM NOSE	S. AUREUS FROM HANDS	S. AUREUS PENICILLIN RESISTANT
Mothers	70	64%	74%	85%
Staff	70	74%	47%	84%
"Normal Women"	100	34%	21%	22%

(c) MOTHERS IN LABOUR.

Vaginal, rectal and nasal swabs were taken in October 1959 from 100 consecutive mothers on commencing labour.

TABLE VII. "CARRIER RATE" OF MOTHERS IN LABOUR

NUMBER SWABBED	S. AUREUS ISOLATED		
	NOSE	VAGINA	RECTUM
100	52	1	4

(d) ENVIRONMENTS.

(i) "ROOMING IN" COTS.

In July, 1959 a surprise "spot check" was done on the technique of "rooming in". This check revealed several minor flaws in technique and one serious source of cross-infection. The cots contain stainless steel bowls for cotton wool and sterile water (Figure 7). These are used by the mothers for any necessary toilet to the baby, which, despite instructions to the contrary often included wiping the eyes of the baby. At the time of the check the water bowl was refilled four hourly from a boiling kettle of water

and emptied by a nurse after use into a bucket by hand.
One afternoon in May 1959, all cotton wool bowls and water bowls from four wards on one floor were swabbed and the swabs cultured.
The following are the results of the cultures.

ROOM 205	Water bowl	(1)	Eight colonies of S. aureus.
	Swab bowl	(1)	No growth.
	Water bowl	(2)	S. albus +
	Swab bowl	(2)	One colony of S. aureus.
	Water bowl	(3)	S. albus +
	Swab bowl	(3)	S. albus +, and Gram negative bacilli.
ROOM 206	Water bowl		One colony of S. albus.
	Swab bowl		S. albus +
ROOM 207	Water bowl	(1)	Proteus ++, and S. albus +
	Swab bowl	(1)	Proteus ++, and S. albus +
	Water bowl	(2)	S. albus +
	Swab bowl	(2)	20 colonies of S. aureus.
	Water bowl	(3)	10 colonies of S. aureus and 15 colonies of Bact. coli.
	Swab bowl	(3)	Three colonies of S. aureus.
	Water bowl	(4)	10 colonies of S. aureus.
	Swab bowl	(4)	One colony of S. albus.
ROOM 209	Water bowl		S. albus +
	Swab bowl		S. albus +

(11) DELIVERY ROOMS.

In July 1959, a similar "spot check" of the"sterile delivery trolleys" in the eight labour wards was performed. These trolleys were made up following each delivery and anything from one hour to two days could elapse before next use.

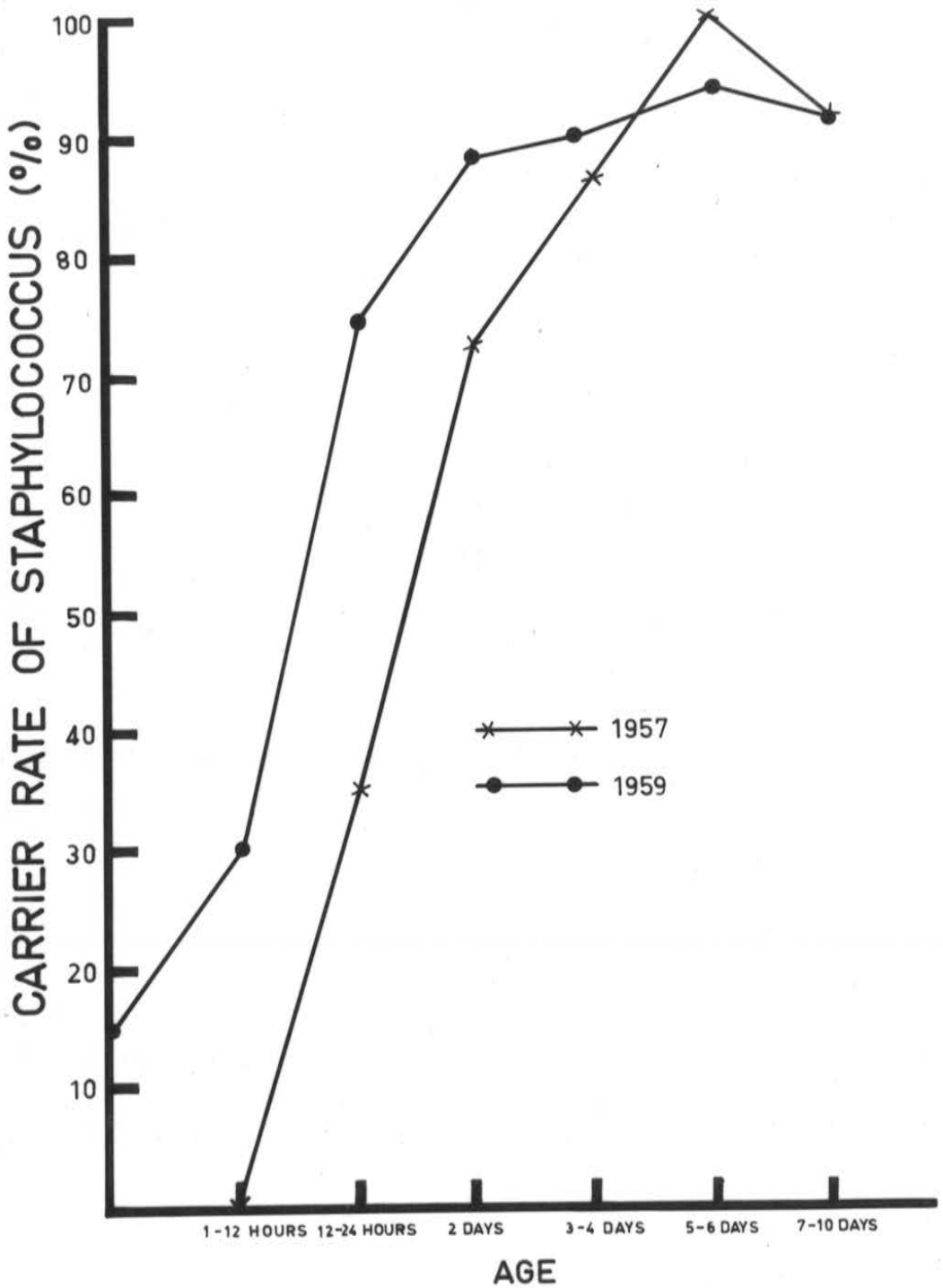

FIG. 10 COMPARISON OF INFANT CARRIER RATES 1957 & 1959

It was routine to include a small stainless steel bowl containing "sterile" water and cotton wool swabs on the trolleys and these were generally used for wiping the eyes of the baby at birth. The "spot check" resulted in a growth of five colonies of S. aureus from a swab from one bowl. The trolleys are now made up daily if used or not.

3. SUMMARY.

With the implementation of the general recommendations the incidence of staphylococcal disease slowly fell in the babies (Figure 9).

"Rooming in" appeared to be a very real factor in the maintenance of this improvement and a breakdown in its practice during April, May and June 1959, was reflected by an increased incidence of staphylococcal disease in the new-born (Figure 9).

The "carrier rate" of the staphylococcus on the hands of mothers rose from 12.0% in 1957 to 74.0% in 1959. The organisms isolated showed a different sensitivity to penicillin from those isolated from the hands of "normal" women. The increased handling of the babies by their mothers with "rooming in" was apparently responsible for this marked rise in hand "carrier rate" of mothers (Table VI).

The marked decrease in the incidence of staphylococcal disease and the lessening of severity of the lesions in the new-born in 1959 was not accompanied by a corresponding fall in the infant "carrier rate" of staphylococci when compared with that of 1957 (Figure 10).

The necessity for adequate bacteriological investigations and the need for constant vigilance in checking nursing technique was shown by "spot checks" carried out in the wards and in the delivery suite in July 1959. These checks were a further demonstration of the complete ubiquity of the staphylococcus and also a practical method of maintaining the interest and co-operation of the nursing staff.

VI. 1960 - CHEMICAL SUBSTANCES APPLIED TO SKIN OF BABY.

"La force de résistance aux antiseptiques en général, ainsi que la faculté d'accommodation que nous venons de mentionner, sont différentes dans les divers microorganismes."

M.G. Kossiakoff, PARIS (1887).

1. INTRODUCTION.

Many hospitals have approached the problem of the staphylococcus and the new-born child by concentrating on lowering the nasal "carrier rate" in both the baby and nursing staff. The results have been heartening and there is undoubtedly justification for the use of an antibiotic cream in the nose when combating temporary outbreaks of severer and more prevalent staphylococcal disease. It is possible, particularly in the baby, that the removal of one organism may well make the way clear for colonization of the nose by another more troublesome organism and the constant use of these substances in the nose has been questioned (Rountree & Barbour 1951, Monro & Markham 1958).

Other workers have concentrated on investigating the application of substances such as hexachlorophene and chlorhexidine to the skin of the baby in attempts to kill any staphylococcus lodging there. (Gillespie, Simpson & Tozer 1958, Hill, Butler & Laver 1959, Simpson, Tozer & Gillespie 1960). Hill and co-workers at the Royal Women's Hospital, Melbourne, by "dry washing" babies with hexachlorophene emulsion, reported a reduction in staphylococcal disease in six months from 15% to 1.3% of the babies born.

The results are convincing but I considered that there may be other factors playing as large a part as the chemical substance itself. For instance, the use of special methods keeps the problem constantly before all people handling the babies and will result in added care and vigilance and better observation of the first principles of asepsis.

The very best that can be said of antisepsis is that it is but a part answer in the control of any infectious disease (Kossiakoff 1887). 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 new-born.

In January 1960, a substance almost identical in appearance and consistency to the commercially manufactured hexachlorophene emulsion (phisohex) was prepared in the pharmacy of the Geelong & District Hospital.

(a) Phisohex. (Winthrop Laboratories)

An antibacterial sudsing detergent in the form of a creamy emulsion and containing -

Entsufon (a detergent)
Lanolin cholesterols
Paraffin
3% (W/W) Hexachlorophene

(b) Geelong Hospital Emulsion.

Of almost the same appearance and consistency as phisohex but leaving a slightly greasy covering on the skin after application and containing no hexachlorophene. The formula is as follows:-

Arachis Oil	50 ml.
Adeps Lanae	22 g.
Lanette Wax N.	67 g.
Glycerin	67 ml.
Alkethoz "Lissapol" (detergent)	20 ml.
Oil of Neroli (perfume)	1.2 ml.
Distilled Water	870 ml.

Commencing in January 1960, all babies born in Baxter House were treated with one or other of the emulsions in a manner similar

to that used by Hill et al (1959) in the application of hexachlorophene emulsion to babies at the Royal Women's Hospital, Melbourne.

The nursing staff of Baxter House were issued with the following instructions concerning the application of the emulsions to babies.

"In The Nurseries Approximately 30 Minutes After Birth

Babies will be treated as follows:-

2 c.c.s. of emulsion will be delivered on to a cotton wool swab from the dispenser supplied (each depression of the plunger will dispense 1 c.c.). The sister will then swab the entire body surface of the baby with the emulsion paying particular attention to the scalp, the skin creases of the neck, axillae, groins and natal clefts. A swab moistened in warm tap water is then taken and again the baby is thoroughly swabbed. A lather will be obtained by this procedure. The lather is then wiped off by cotton wool and the baby dried. 1 c.c. of the emulsion is now taken on another swab and wiped over the whole skin surface, again taking particular care to cover the skin creases. This is allowed to dry on the baby. The baby is then dressed in the usual manner.

If there are excessive amounts of vernix or meconium, the initial 2 c.c.s. of emulsion may need to be increased. The sister performing the treatment will wear sterile gloves.

Post-Natal Treatment

(a) Normal babies will be treated on alternate days following birth. Whenever possible the mother will carry out treatment under the supervision of the nursing staff.

(b) Sick and Nursery babies will be dealt with by the sisters and mothercraft nurses as in opening instructions.

(c) Caesarean Section babies will be dealt with initially by the sisters soon after the arrival from theatre and thereafter by the mother when she is fit to handle her own baby.

(d) Premature babies will be treated as in the opening instructions and this will commence when the baby's condition allows and thereafter at each weighing or when the opportunity offers.

Routine Oiling of Babies

This will cease following the introduction of this procedure. Water only is to be used for cleansing the buttocks etc. This also applies to premature babies.

Olive Oil or Ointments

These are not to be used unless they are specially ordered by the baby's own doctor.

Treatment of the Cord will be as Follows:

The baby will arrive from the delivery suite with a sterile dressing and binder on the cord. After the baby has been treated with the emulsion, re-tie the cord if necessary and apply a sterile dressing and the binder.

12 hours after the birth or later the cord is re-tied and painted with 1.25% (W/V) iodine in alcohol. This must be done with a swab stick and care taken to see that the baby's skin about the umbilicus is not burnt with the iodine. The cord is then left without a dressing and binder and painted once daily until the cord has separated. In the "rooming in" technique the mother is to be instructed to hold the cord up while the sister paints it. When the nursing staff handle the cord they must scrub as for a sterile procedure."

"Dry washing" the babies commenced on January 1st.1960. The Ground and Second Floors were issued with phisohex. The First and Third Floors were issued with the Geelong Hospital Emulsion.

The medical profession and nursing staff were told that both emulsions were identical and that the only difference lay in the Geelong Hospital Emulsion being prepared in the hospital pharmacy

and consequently 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 of the impression that both preparations contained hexachlorophene.

On April 1st. 1960, all dispensers and stock bottles were cleaned out and phisohex was issued to the First and Third Floors, and the Geelong Hospital Emulsion issued to the Ground and Second Floors.

2. BACTERIOLOGICAL METHODS. THE USE OF POLYSORBATE 80.

Polysorbate 80 ("Tween 80"), is a complex mixture of polyoxyethylene ethers of mixed partial oleic esters of sorbital anhydrides. "In vitro", it possesses an inhibiting action on the bacteriostatic power of hexachlorophene (Lawrence and Erlandson 1953, Erlandson and Lawrence 1953, Smylie, Webster and Bruce 1959).

It was considered that the introduction of phisohex and the Geelong Hospital Emulsion might invalidate the results of cultures taken by leaving minute residual amounts of the emulsions adhering to swabs taken from skin lesions. In view of this the following tests were designed to assess and eliminate any such possibility.

(a) Culture plates containing 1% polysorbate 80 in nutrient agar were flooded with serial dilutions of phisohex. The excess fluid was pipetted off and the plates then dried in an incubator at 37° C.

(b) Similar plates were flooded with serial dilutions of the Geelong Hospital Emulsion and the excess pipetted off and the plates dried.

(c) All plates were inoculated with one drop of a six hour broth culture of a local staphylococcus (S. aureus, strain LOWTHIAN, phage type 80/81) spread on the plates with a wire loop.

The growth resulting from these cultures is shown in Table VIII.

TABLE VIII. BACTERIOCIDAL EFFECT OF POLYSORBATE 80 ON S. AUREUS IN PRESENCE OF PHISOHEX AND GEELONG HOSPITAL EMULSION

DILUTION OF EMULSION	PHISOHEX		GEELONG HOSPITAL EMULSION	
	CONTROL PLATE	POLYSORBATE PLATE	CONTROL PLATE	POLYSORBATE PLATE
1 : 5	No growth	+++	+++	++++
1 : 10	No growth	+++	+++	++++
1 : 50	No growth	++++	+++	++++
1 : 100	No growth	++++	+++	++++
1 : 500	No growth	++++	++++	++++
1 : 1000	No growth	++++	++++	++++

A similar test of dilutions of the two emulsions was done to assess the effect of the emulsions on the growth of organisms other than Staphylococcus aureus (Table IX).

TABLE IX. ACTION OF PHISOHEX, GEELONG HOSPITAL EMULSION AND POLYSORBATE 80 ON VARIOUS ORGANISMS

ORGANISM	DILUTION OF EMULSION	PHISOHEX			GEELONG HOSPITAL EMULSION		
		BLOOD AGAR	NUTRIENT AGAR	POLY SORBATE AGAR	BLOOD AGAR	NUTRIENT AGAR	POLY SORBATE AGAR
STREP. VIRISANS	1 : 10	N.G.	N.G.	+	++++	++	+++
	1 : 100	+	N.G.	N.G.	++++	++++	N.G.
	1 : 500	++++	N.G.	N.G.	++++	++++	N.G.
BACT. COLI	1 : 10	++++	++	++++	++++	++++	++++
	1 : 100	++++	++++	++++	++++	++++	++++
	1 : 500	++++	++++	++++	++++	++++	++++
PROTEUS VALGARIS	1 : 10	++++	N.G.	++++	++++	++++	++++
	1 : 100	++++	++++	++++	++++	++++	++++
	1 : 500	++++	++++	++++	++++	++++	++++
Ps. PYOCYANEUS	1 : 10	++++	++++	++++	++++	++++	++++
	1 : 100	++++	++++	++++	++++	++++	++++
	1 : 500	++++	++++	++++	++++	++++	++++
MONILIA ALBICANS	1 : 20	++++	++++	++++	++++	++++	++++
	1 : 400	++++	++++	++++	++++	++++	++++

Consideration of Tables VIII and IX shows the following.

(a) Polysorbate 80 is an efficient inactivator of phisohex "in vitro."

(b) Polysorbate 80 has no bacteriocidal effect on the organisms tested, other than Streptococcus viridans.

(c) The Geelong Hospital Emulsion has slight if any bacteriocidal effect.

(d) Phisohex has but very slight bacteriocidal effect on any organism other than the staphylococcus and streptococcus.

As a result of these findings all swabs taken from Baxter House in 1960 were immediately plated on a nutrient agar plate containing 1% (V/V) polysorbate 80 in addition to horse blood agar and "salty broth" as previously.

3. INCIDENCE OF STAPHYLOCOCCAL DISEASE IN NEW-BORN WITH "DRY WASHING".

Table X shows the incidence of staphylococcal disease in the new-born following the introduction of "dry washing" the babies with phisohex and the Geelong Hospital Emulsion on January 1st 1960. The incidence is recorded in three month periods.

TABLE X. RECORDED INCIDENCE OF STAPHYLOCOCCAL DISEASE IN NEW-BORN. JANUARY - SEPTEMBER 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%

Phisohex was used on the Ground and Second Floors during the first and third three month period and the Geelong Hospital Emulsion during the period April - June 1960 (Table XI).

TABLE XI. RECORDED INCIDENCE OF STAPHYLOCOCCAL DISEASE ON GROUND AND SECOND FLOORS. JANUARY - SEPTEMBER 1960.

1960	BABIES BORN	STAPHYLOCOCCAL DISEASE	
		ALL LESIONS	SKIN LESIONS
January - March (PHISOHEX)	325	5.5%	0.9%
April - June (Geelong Hospital Emulsion)	337	8.6%	3.6%
July - September (PHISOHEX)	352	4.5%	1.4%

The Geelong Hospital Emulsion was used on the First and Third Floors during the first and third three month period and phisohex was used during the period April - June 1960 (Table XII).

TABLE XII. RECORDED INCIDENCE OF STAPHYLOCOCCAL DISEASE ON FIRST AND THIRD FLOORS. JANUARY - SEPTEMBER 1960.

1960	BABIES BORN	STAPHYLOCOCCAL DISEASE	
		ALL LESIONS	SKIN LESIONS
January - March (Geelong Hospital Emulsion)	304	1.6%	0.3%
April - June (PHISOHEX)	291	4.1%	1.7%
July - September (Geelong Hospital (Emulsion)	319	6.0%	4.4%

4. "CARRIER RATE" OF STAPHYLOCOCCUS AUREUS DURING "DRY WASHING".

Swabs were taken at delivery from both eyes, the nose, and umbilicus of ten consecutive babies born during February, March, April, May and June 1960. There was no selection of these babies regarding the day in the month that each series was commenced or the probable floor to which the infant would be sent. The mothers of these babies were swabbed from both nostrils, on admission in labour and on the day of discharge from hospital.

The babies were again swabbed from all sites within 48 hours of delivery, again on the third or fourth days, then on the fifth or sixth day and finally in the hospital on the seventh, eighth, ninth or tenth day. This swabbing was repeated at home during the third and sixth week after birth.

(a) INFANT "CARRIER RATE" 1960.

TABLE XIII. INFANT "CARRIER RATE" IN HOSPITAL AND AT HOME.

AGE OF BABIES	NUMBER SWABBED	NO. GROWING S. AUREUS	SITE OF POSITIVE SWABS		
			EYES	UMBILICUS	NOSE
At Birth	50	5	2	-	3
1 - 24 hrs.	27	7	3	4	3
2 days	23	8	3	5	2
3 or 4 days	50	29	19	15	12
5 or 6 days	50	24	15	18	15
7,8,9 or 10 days	32	20	16	9	17
3 weeks	38	23	10	11	17
6 weeks	38	25	15	14	22

Table XIV and XV show respectively the "carrier rate" of these infants "dry washed" with phisohex and those with the Geelong Hospital Emulsion.

TABLE XIV. "CARRIER RATE" OF INFANTS "DRY WASHED" WITH PHISOHEX

AGE OF BABIES	NUMBER SWABBED	S. AUREUS GROWN	SITE OF POSITIVE SWABS			
			EYES	UMBILICUS	NOSE	TOTAL
At birth	24	2	2	-	-	2
1 - 24 hrs	14	2	-	2	-	2
2 days	10	2	1	1	-	2
3 & 4 days	24	10	6	6	5	17
5 & 6 days	24	8	4	6	7	17
7 - 9 days	12	6	4	4	5	13
3 weeks	19	9	3	7	8	18
6 weeks	19	10	6	5	8	19

TABLE XV. "CARRIER RATE" OF INFANTS "DRY WASHED" WITH GEELONG HOSPITAL EMULSION.

AGE OF BABIES	NUMBER SWABBED	S. AUREUS GROWN	SITE OF POSITIVE SWABS			
			EYES	UMBILICUS	NOSE	TOTAL
At birth	26	3	-	-	3	3
1 - 24 hrs	13	5	2	1	3	6
2 days	13	6	2	4	2	8
3 & 4 days	26	19	13	9	7	29
5 & 6 days	20	16	11	12	8	31
7 - 9 days	20	14	12	5	12	29
3 weeks	19	14	8	4	9	21
6 weeks	19	15	9	9	14	32

(b) MOTHERS.

The mothers of the babies in Table XIII were swabbed from both nostrils on admission in labour and again on discharge home with their babies. The time of discharge from hospital varied from six to ten days after admission. More mothers were nasal carriers on discharge from hospital than on admission to hospital (Table XVI).

No mothers or babies were treated with antibiotic nasal ointments. The staphylococcus was an ever changing inhabitant of the mother's nose, e.g. five mothers who were nasal carriers of staphylococci on admission gave negative nasal cultures on discharge from hospital.

TABLE XVI. NASAL "CARRIER RATE" OF MOTHERS ON ADMISSION AND ON DISCHARGE FROM HOSPITAL. JANUARY - JUNE 1960.

	ON ADMISSION		ON DISCHARGE	
	NUMBER	POSITIVE	NUMBER	POSITIVE
INFANT "DRY WASHED" WITH PHISOHEX	24	11	23	11
INFANT "DRY WASHED" WITH GEELONG HOSPITAL EMULSION	26	8	25	13
TOTAL	50	19	48	24

5. SUMMARY.

The introduction of a method of "dry washing" the babies was followed by a marked decrease in the recorded incidence of staphylococcal disease in the new-born (Table X). This decrease applied

to those floors using the Geelong Hospital Emulsion as well as those using phisohex (Tables XI & XII).

The record low incidence of staphylococcal disease showed a slight increase in the second three month period but fell again in July 1960. At no time was the incidence greater than the lowest level attained prior to "dry washing" (Table X). Those floors using phisohex maintained a lower incidence of staphylococcal disease than the floors using the Geelong Hospital Emulsion (Tables XI & XII).

The overall "carrier rate" of the babies was still high but showed a definite decrease over that of 1959 when 90% of babies were carriers by the 4th day of life. In 1960 only 58% of babies carried the staphylococcus by the 4th day of life (Tables V & XIII).

The presence of hexachlorophene in the emulsion used for "dry washing" babies was a greater means of lowering the infant "carrier rate" than "dry washing" without added hexachlorophene (Tables XIV & XV). It can be seen that by the 4th day of life 41% of the babies washed with phisohex and 73% of the babies washed with the Geelong Hospital Emulsion carried the staphylococcus.

The number of mothers and their variance in nasal "carrier rate" was not great enough to be significant but the impression was gathered that the nasal "carrier rate" was lowered in mothers when their infants were "dry washed" with an emulsion containing hexachlorophene (Table XVI).

VII. OTHER ASPECTS OF SURVEY. 1956 - 1960.

> "The mention of the organisms that exist on the surfaces of the human body naturally suggests the inquiry, are they innocent or noxious?"
>
> Sir Alexander Ogston, ABERDEEN (1882).

1. ANTIBIOTIC SENSITIVITY OF STAPHYLOCOCCI ISOLATED.

It is not the purpose of this thesis to discuss the problems associated with the use or misuse of antibiotics and the emergence of antibiotic resistant staphylococci. All that will be attempted is to use the sensitivity of the staphylococcus to penicillin and tetracyline as a supplementary aid in studying the epidemiology of staphylococcal disease in the new-born.

Table XVII compares the antibiotic pattern of the staphylococci isolated in the maternity wing with that of the strains isolated from the general wards of the Geelong & District Hospital and from the general community outside the hospital. It will be seen from this table that the antibiotic pattern of the strains isolated from Baxter House is similar to that of the staphylococci found in the general population and unlike the overall sensitivity pattern of the staphylococci cultured from medical and surgical conditions present in the general wards of the Geelong & District Hospital.

TABLE XVII. ANTIBIOTIC PATTERN. JULY 1956 - JUNE 1960.
GENERAL WARDS. MATERNITY WING. GENERAL POPULATION.

YEAR	ANTIBIOTIC PATTERN	GENERAL WARDS	MATERNITY WING	GENERAL POPULATION	TOTAL
1956	No. of Strains	90	507	60	657
	Pen. Resist.(%)	85.5	99.4	85.0	96.2
	Tet. Resist.(%)	27.8	16.2	10.0	17.2
1957	No. of Strains	380	1066	243	1689
	Pen. Resist.(%)	87.6	72.9	65.4	75.2
	Tet. Resist.(%)	33.7	8.3	6.5	13.8
1958	No. of Strains	333	455	167	955
	Pen. Resist.(%)	81.7	57.1	52.7	64.8
	Tet. Resist.(%)	42.6	11.4	9.5	22.0
1959	No. of Strains	329	1406	216	1951
	Pen. Resist.(%)	80.9	68.4	59.7	69.5
	Tet. Resist.(%)	34.3	10.5	12.0	14.7
1960	No. of Strains	153	302	146	601
	Pen. Resist.(%)	83.0	57.0	60.3	64.4
	Tet. Resist.(%)	38.6	11.6	9.7	18.0
1956 to 1960	No. of Strains	1285	3736	832	5853
	Pen. Resist.(%)	83.7	71.9	61.9	72.9
	Tet. Resist.(%)	36.4	10.5	9.4	16.3

The 3736 strains isolated from the maternity wing include 2025 staphylococci from babies with staphylococcal disease. The latter are compared with lesions from the general wards of the Geelong & District Hospital in Table XVIII. This table shows that the antibiotic pattern found in the staphylococci isolated from lesions in the general wards is different from the overall sensitivity pattern of the staphylococci causing disease in the new-born.

TABLE XVIII. ANTIBIOTIC PATTERN OF STAPHYLOCOCCI ISOLATED FROM LESIONS IN THE NEW-BORN AND IN THE GENERAL WARDS. 1956 - 1960.

	STAPHYLOCOCCAL DISEASE OF NEW-BORN	GENERAL WARDS		
		MEDICAL	SURGICAL	CHILDREN
Number of Strains	2025	433	593	259
Penicillin Resistant	70.7%	78.5%	87.0%	84.5%
Tetracyline Resistant	12.5%	35.8%	45.8%	19.3%

1711 of the 3736 strains of staphylococci isolated in Baxter House were from various "carrier rate" surveys and of these some 203 were from either the hands or nose of nursing staff. The antibiotic pattern of the latter is compared with that of staphylococci isolated from staphylococcal lesions of the new-born and from "carrier rate" survey of the mothers, babies and environment in Table XIX.

TABLE XIX. ANTIBIOTIC PATTERN OF STAPHYLOCOCCI ISOLATED IN BAXTER HOUSE. 1956 - 1960.

	STAPHYLOCOCCAL DISEASE OF NEW-BORN	MOTHER, BABY & ENVIRONMENT	NURSING STAFF	TOTAL ALL CATEGORIES
Number of Strains	2025	1508	203	3736
Penicillin Resistant	70.7%	71.0%	85.2%	71.9%
Tetracycline Resistant	12.5%	8.0%	15.2%	10.5%

The nursing staff of the maternity wing is quite separate from that of the general wards of the Geelong & District Hospital but for sharing a common dining room and Nurses' Home.

A study of Tables XVII, XVIII & XIX showed the following trends in the antibiotic pattern of staphylococci isolated.

(a) The pattern of the strains isolated from lesions of the new-born tended to follow that of the staphylococci isolated in "carrier rate" surveys of Baxter House and from the general community.

(b) The overall pattern of strains isolated from lesions of the new-born was different from that of medical and surgical infections in the General wards of the Geelong & District Hospital.

(c) The antibiotic pattern of the staphylococci carried on the hands and nose of nursing staff in the maternity wing does not closely follow the pattern of strains from medical and surgical infections or that of staphylococcal disease in the new-born.

A study of the antibiotic pattern of staphylococci isolated gives the impression that there was not a particular "Hospital Staph." responsible for the high incidence of staphylococcal disease among the new-born in Geelong.

2. BACTERIOPHAGE TYPES OF STAPHYLOCOCCI ISOLATED.

The relation of the various phage groups of staphylococci isolated to disease in the new-born will be more fully discussed in Part VIII of this thesis. The present section mainly considers the phage patterns from an epidemiological point of view.

230 staphylococci isolated from lesions of the new-born were phage typed in 1957 and in 1959 - 1960 (Table XX). At no period did any group assume epidemic proportions and although phage pattern 80/81 was always prominent, it was never strongly so as in many reports from maternity hospitals in Australia and elsewhere in the world (Rountree and Freeman 1955, Gillespie and Alder 1957, Munro and Markham 1958, Tinbury, Wilson, Hutchison and Govan 1958, Williams 1959, Hardyment, Wilson, Cockcroft and Johnson 1960).

TABLE XX. PHAGE GROUP DISTRIBUTION OF STAPHYLOCOCCI ISOLATED FROM LESIONS OF NEW-BORN.

PHAGE GROUP	STAPHYLOCOCCAL DISEASE OF NEW-BORN		
	1957	1959 - 60	TOTAL
Group I			
80/81	13.2%	7.8%	8.7%
Others	18.4%	2.6%	5.2%
Group II	5.3%	7.3%	7.0%
Group III	44.7%	15.1%	20.0%
Miscellaneous	2.6%	3.1%	3.0%
Non-Typable	15.8%	64.1%	56.1%
TOTAL STRAINS	38	192	230

The term phage pattern 80/81 has been used for convenience to include the strains typing as 52/80/81, 52/52A/80/81, 80/81 and 81, as all these have been found to be closely related (Asheshov & Rippon 1959, and Rountree 1959).

Timbury et al (1958) reported that the introduction of type 80 to the Royal Maternity Hospital, Glasgow was closely followed by a sudden and dramatic increase in the severity of infections among the babies and like other workers regarded the strain as unusually virulent. They were also of the opinion that type 80 did not have great powers of colonisation and showed no tendency to persist unduly in the nose of infected infants and staff. It was impossible to come to any similar deduction from the phage groups of staphylococci isolated in the various surveys of Baxter House. These did not appear to demonstrate features in staphylococci of phage pattern 80/81 which were different from those found in staphylococci of other phage groups. The distribution of strains in both the "carrier state" and in pathological lesions was similar, in fact phage pattern 80/81 was more frequent in the "carrier state" on normal babies than in lesions (Table XXI).

TABLE XXI. PHAGE GROUP DISTRIBUTION OF STAPHYLOCOCCI ISOLATED FROM LESIONS AND "CARRIER RATE" SURVEYS IN BAXTER HOUSE.

PHAGE GROUP	STAPHYLOCOCCAL DISEASE OF NEW-BORN	"CARRIER RATE" SURVEYS
Group I		
80/81	8.7%	13.5%
Others	5.2%	4.9%
Group II	7.0%	7.0%
Group III	20.0%	15.7%
Miscellaneous	3.0%	2.7%
Non-typable	56.1%	56.2%
TOTAL STRAINS	230	370

A comparison is made in Table XXII of the phage groups of those staphylococci isolated in the "carrier rate" surveys conducted among babies, mothers and nursing staff in 1957 and in 1959 - 60. It can be seen that the nursing staff carried a greater percentage of staphylococci of phage pattern 80/81 than either the mothers or babies.

TABLE XXII. PHAGE GROUP DISTRIBUTION OF STAPHYLOCOCCI ISOLATED DURING "CARRIER RATE" SURVEYS IN BAXTER HOUSE.

PHAGE GROUP	BABIES	MOTHERS	NURSING STAFF		
	1959-60	1959-60	1957	1959-60	1957-60
Group I					
80/81	9.9%	9.4%	23.5%	19.7%	21.3%
Others	2.1%	3.8%	15.7%	5.6%	9.8%
Group II	6.3%	4.8%	13.7%	7.0%	9.8%
Group III	12.0%	22.6%	13.7%	14.1%	13.9%
Miscellaneous	3.5%	0.9%	7.9%	-	3.4%
Non-Typable	66.2%	58.5%	25.5%	53.6%	41.8%
TOTAL STRAINS	142	106	51	71	122

A comparison is made in Table XXIII of the phage group distribution of staphylococci isolated in Baxter House during the years 1959 to 1960. This shows that the distribution of phage groups in babies was similar in both the"carrier state" and in strains from lesions. These in turn were similar to the staphylococci carried by the mothers and in the overall comparison less like those carried by the nursing staff. This same feature in the distribution of phage groups was shown in Table XXII. These findings are the reverse of those of Hardyment et al (1960) who found "more similarity" between the phage types of organisms from the babies and nurses than between the babies and mothers.

TABLE XXIII. PHAGE GROUP DISTRIBUTION OF STAPHYLOCOCCI ISOLATED IN BAXTER HOUSE. 1959 - 1960.

PHAGE GROUP	"CARRIER RATE" SURVEYS			LESIONS OF NEW-BORN	ALL CATEGORIES
	BABIES	MOTHERS	NURSING STAFF		
Group I					
80/81	9.9%	9.4%	19.7%	7.8%	10.4%
Others	2.1%	3.8%	5.6%	2.6%	3.1%
Group II	6.3%	4.8%	7.0%	7.3%	6.5%
Group III	12.0%	22.6%	14.1%	15.1%	15.6%
Miscellaneous	3.5%	0.9%	-	3.1%	2.4%
Non-Typable	66.2%	58.5%	53.6%	64.1%	62.0%
TOTAL STRAINS	142	106	71	192	511

A striking feature of Table XXIII is the very high percentage of non-typable staphylococci (62.0%). This was considered at first to be a possible error in technique but thorough re-checking and typing of these strains by Dr. Hildred Butler of the Royal Women's Hospital, Melbourne reproduced the same result and has shown these strains to be non-typable.

A similar high incidence of non-typable strains was found in the staphylococci isolated from pathological conditions in the Geelong & District Hospital in 1960 (Table XXIV). These staphylococci were isolated from medical and surgical wards and autopsy and came from varying conditions including staphylococcal septicaemia and pneumonia, osteomyelitis, bacterial endocarditis, breast abscess, wound infection, otitis media, urinary infection, impetigo contagiosa, paronychia and a variety of other conditions. A similar high percentage (69.5%) of non-typable strains was found in the "carrier state" in the non-hospital population of Geelong in the period 1959 - 60 (Table XXIV).

TABLE XXIV. PHAGE GROUP DISTRIBUTION OF STRAINS FROM THE GENERAL WARDS AND NORMAL POPULATION.

PHAGE GROUP	GENERAL WARDS			NORMAL POPULATION
	PATHOLOGICAL LESIONS		TOTAL	
	1957-59	1960	1957-60	1959-60
Group I				
80/81	66.2%	10.0%	26.0%	2.4%
Others	1.8%	2.9%	2.6%	1.3%
Group II	5.3%	4.2%	4.6%	12.2%
Group III	10.7%	9.2%	9.7%	14.6%
Miscellaneous	5.3%	1.4%	2.6%	-
Non-Typable	10.7%	71.3%	54.5%	69.5%
TOTAL STRAINS	56	140	196	82

The National Health & Medical Research Council (N.H.M.R.C. Special Report 1960) conducted a survey between May and December 1958, of staphylococcal infections of the skin and subcutaneous tissues in general practice in all states of Australia, other than Northern Territory. Only 9.4% of 1614 strains from lesions were non-typable, and 17.5% of 726 strains from nasal carriers were non-typable. Barker and Burston (1955) record only 6.9% non-typable strains among 145 staphylococci isolated from nurses, mothers and babies in a maternity unit in London . These reports agree with the findings of Hardyment et al (1960) in Vancouver and differ completely from the percentage of non-typable strains found in Geelong in 1959 and 1960. The 882 strains phage typed in Geelong are grouped together in Table XXV.

TABLE XXV. PHAGE GROUP DISTRIBUTION OF STAPHYLOCOCCI ISOLATED IN GEELONG. 1957 - 1960.

PHAGE GROUP	BAXTER HOUSE	GENERAL WARDS	MISCELLANEOUS SOURCES	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%
Group 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

The question of the high ratio of non-typable strains in Geelong is confusing and no explanation as yet can be given. It is considered that it is definitely not due to a fault in the technique of phage typing as strains from other areas which were bacteriophage typed in the same batch of tests did not yield a similar high percentage of non-typable strains. Several local phages have been isolated but have been lost on attempts at propogation. A few of the non-typable strains have lysed with a Melbourne phage (Phage "A") isolated in 1960 by Dr. Hildred Butler. The percentage of non-typable strains also appears to be increasing in both the pathological and "carrier state" and is the subject of further investigation.

3. SEVERE STAPHYLOCOCCAL DISEASE IN THE FIRST SIX MONTHS OF LIFE.

A very complete follow up of all babies born in Geelong and the surrounding districts was possible for the following reasons.

(a) Baxter House provides all the maternity beds for a fairly compact community.

(b) The Geelong & District Hospital provides more than 90% of the public and private hospital beds available to the population of Geelong and its surrounding districts.

(c) There was complete co-operation during the survey by all medical practitioners and consequently it was possible to include both public and private patients in the surveys.

(d) The Geelong & District Hospital maintains a 98% autopsy rate on public patients and provides the facilities for the conduct of all post mortems on deaths coming under the jurisdiction of the coroner.

Due to the above factors the statistics are considered virtually complete. They were derived from public and private hospital records and coronial autopsies and were further supplemented and cross-checked by pro-formas circulated to all local medical practitioners at regular intervals. These forms were simple and only required the names of any mother developing a breast abscess in the first six months after delivery, and the names of infants admitted to hospital or dying as a result of staphylococcal disease in the first six months of life. (p.97). The names received were back checked and correlated with the information compiled from public and private hospital records and coronial autopsies.

The number of infants requiring hospitalization or dying as a result of staphylococcal disease in the first six months of life is shown in Table XXVI.

TABLE XXVI. INFANTS DEVELOPING SEVERE STAPHYLOCOCCAL DISEASE IN FIRST SIX MONTHS OF LIFE. JULY 1956 - SEPTEMBER 1960.

	1956 (6 months)	1957	1958	1959	1960 (9 months)	TOTAL
Infants Born In Baxter House	1298	2419	2323	2433	1928	10,401
Number Requiring Hospitalization As Result Of Staphylococcal Disease	6	11	7	7	-	31
Deaths In First Six Months Of Life	1	4	2	1	-	8*

* EIGHT DEATHS DUE TO FOLLOWING -

Pneumonia	Six cases.
Septicaemia	One case.
Peritonitis	One case.

Table XXVI shows that very few infants (0.30%) were re-admitted to hospital as a result of staphylococcal disease and less than 0.1% of the infants born died from staphylococcal disease in the first six months of life. Even such a low morbidity and mortality showed a definite increase when the incidence of staphylococcal disease in the new-born was high as occurred in 1956 and 1957. Conversely in the first nine months of 1960 when the incidence of staphylococcal disease in the new-born was very low, there were no deaths nor were any infants re-admitted to hospital as a result of severe staphylococcal disease.

4. MORBIDITY IN MOTHERS - BREAST ABSCESS.

Approximately 90% of mothers were followed for six months after delivery in order to elicit the incidence of breast abscess (Table XXVII). In order to give an absolute criterion only those breast abscesses which required either treatment in hospital, incision in the surgery or at home, or those which

suppurated were included in this table. Breast infections which completely resolved under chemotherapy were not included.

TABLE XXVII. INCIDENCE OF BREAST ABSCESS IN MOTHERS. JULY 1956 - SEPTEMBER 1960.

	1956 (6 months)	1957	1958	1959	1960 (9 months)	TOTAL
Number of Mothers	1091	2003	2024	2320	1853	9291
Number of Breast Abscesses In Six Months Following Delivery	27	31	20	18	12	108
% of Mothers Developing Breast abscess	2.5%	1.5%	1.0%	0.78%	0.60%	1.16%

It can be seen that the incidence of breast abscess remained relatively low even when staphylococcal disease of the new-born was prevalent in Baxter House as in 1956 and 1957. Knight and Nolan (1959) estimated from a review of hospital records that between 3 - 4% of all women delivered in Edinburgh in 1957, developed breast abscess. Table XXVII also demonstrated a definite lowering in the incidence of breast abscess in mothers in 1958 and 1959 when staphylococcal disease in the new-born was less. There was a further decrease to 0.60% in 1960 with the introduction of "dry-washing". A similar reduction was noted by Corner, Crowther and Eades (1960) who recorded a drop in incidence of breast abscess in mothers from 2.4% to 0.6% following the use on the babies of a dusting powder containing hexachlorophene.

VIII. GENERAL DISCUSSION.

> "Let us try to analyze the plot of this story or drama which repeats itself in such different contexts and in such various forms."
>
> A.J. Toynbee, "The Study of History," Part II.C.

This study of staphylococcal disease in the new-born was commenced 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 & District Hospital.

In 1955, Ravenholt and La Veck (1956) wrote to 26 hospitals in Seattle - King County asking them about their experience of staphylococcal disease and from the replies received said, "Staphylococcal disease is a major problem in the better hospitals - the ones that have pathologists and good laboratories and a hospital infection record-keeping system. Administrators of hospitals without such resources usually stated that they had no staphylococcal disease problem."

The above statement is again exemplified by looking further into the past. J. L. Henderson, at the Royal Infirmary, Edinburgh, in August 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 XXVIII is from this lecture and gives the incidence of the various types of lesions in the 424 cases of staphylococcal disease of the new-born seen in the Simpson Maternity Hospital, Edinburgh, in 1942.

TABLE XXVIII. TAKEN FROM HONYMAN LECTURE BY J. L. HENDERSON (1943). "THE INCIDENCE OF THE VARIOUS TYPES OF STAPHYLOCOCCAL INFECTION (BASED ON THE TYPE OF THE INITIAL LESION) IN 424 INFANTS IN THE YEAR 1942."

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 424 cases of staphylococcal disease of the new-born referred to in Table XXVIII occurred in approximately 2,800 deliveries. It is not possible to make an exact comparison but this incidence of staphylococcal infection in the Simpson Maternity Hospital in 1942 is very similar to that which occurred in Baxter House between the years 1957 and 1959. There were 2,917 deliveries in Baxter House between January 1st 1958 and March 31st 1959. 420 of these babies developed staphylococcal disease in the first ten days of life and an attempt is made in Table XXIX to classify the various types of lesions in the same way as Henderson did in Table XXVIII.

TABLE XXIX. THE INCIDENCE OF THE VARIOUS TYPES OF STAPHYLOCOCCAL INFECTION (BASED ON THE TYPE OF THE INITIAL LESION) IN 420 INFANTS IN THE YEARS 1958 - 59.

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

It can be seen that there is a striking similarity between the incidence % and number of lesions seen in 1942 and those in 1958 - 59. A comparison of Tables XXVIII and XXIX must make one agree with the following statement of Walsh McDermott (1956). "We have no convincing evidence, or indeed any particularly well founded suspicion, that the crude equilibrium between the public at large and the ubiquitous staphylococcus is shifting for the worse." Despite the truth of this statement, the problem in maternity units has not lessened and staphylococcal lesions are now the most troublesome and disturbing infection with which epidemiologists and obstetricians have to contend.

The present study attempts to assess certain aspects of staphylococcal infection as it applies to the new-born in large maternity units. One of the most complex factors in this problem is the complete ubiquitousness of the staphylococcus and its multiple methods of transmission to the new-born (Figure 6).

Certain avenues of transmission may be temporarily controlled by antibiotics and antisepsis, but these are only ancillary methods of control even in infections where the method of transmission of the responsible organism is simple and well understood.

Asepsis properly understood and conscientiously carried out by all must be the first and main line of attack in any problem of cross-infection. The present investigation has shown that attention to the first principles of aseptic technique in itself markedly lowered the incidence of staphylococcal disease in the new-born in 1957 and 1958 (Figure 9). The possible and probable methods of transmission of the staphylococcus are so numerous in maternity units that some cross-infection is probably not preventible (Figure 6 and Table II) and so constant vigilance and education of every member of the staff is all the more imperative and the statement "Human nature forgets unseen foes" by Sir Alexander Ogston (1883) all the more apt. "Spot checks" demonstrating breakdowns or possible breakdowns in technique (pp. 27 & 28) were a rewarding practical way of showing the staff the need for constant vigilance and always resulted in keen interest and utmost co-operation from the nursing staff with a resultant improvement in nursing technique on all floors.

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. "Barrier" nursing of babies for example is neither practical nor possible in large nurseries where the mere making of a bed can be a dangerous

procedure (Miles, Schwabacher, Cunliffe, Ross, Spooner, Pilcher & Wright 1940). Frazer (1948) studied the effect of nursery design on cross-infection at the Jubilee Maternity Hospital, Belfast. This worker is one of the few who considered that dispersal of babies was more potential danger than use in reducing the incidence of staphylococcal disease in infants. I am convinced that the trend in the past 15 years of grouping infants together in large maternity units has exposed the new-born child to an increased possibility of developing staphylococcal disease.

In 1945 there were 100 midwifery beds in Geelong and these were contained in 11 separate small hospitals of bed states varying from 5 - 25 beds. In 1955 there were 95 midwifery beds in Geelong and all were in Baxter House.

I am convinced that dispersal of infants is an important factor in controlling the spread of staphylococcal disease in the new-born. 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 nursing the mother and baby as an individual unit (Figure 8).

"ROOMING IN."

Whatever the habits of the staphylococcus there are four obvious links in the chain of production of staphylococcal disease in the new-born - 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 many avenues of possible cross-infection will be eliminated, although a fifth possible avenue in the form of visitors may be introduced. The procedure may also expose the infant to an added possibility of cross-infection from its mother.

Despite the latter risks, "rooming in" was without doubt a most important fundamental procedure in decreasing staphylococcal disease in Baxter House (Figure 9). "Rooming in" adds even a 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" unfortunately does suffer certain undermining from both the mothers and 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 new-born 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 to both these groups to overcome this problem.

DELIVERY AND THE STAPHYLOCCCCUS.

Swabs were taken in 1959 and 1960 from 70 babies at birth and again from 48 of these within 24 hours of delivery (Tables V and XIII). These figures are combined in Table XXX which again highlights the ubiquity of the staphylococcus and the high resistance to clinical infection exhibited by man as his entire environment from the labour ward to death bed is apparently strewn with staphylococci.

TABLE XXX. INFANT "CARRIER RATE" WITHIN 24 HOURS OF BIRTH

AGE	NUMBER AT RISK	NUMBER GROWING S. AUREUS	SITE OF POSITIVE SWABS		
			EYES	UMBILICUS	NOSE
At Birth	70	8 (11.4%)	4	-	5
1 - 24 hours	48	18 (37.5%)	4	14	5

It can be seen from Table XXX that 11.4% of babies were 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.

VAGINAL STAPHYLOCOCCI.

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 and found that 15% of 300 consecutive mothers investigated by them were carriers of pathogenic staphylococci in their vagins at confinement. They claim that 82% of these mothers infected their baby during labour.

I am of the opinion that the vagina plays but a minor part in infecting the baby with staphylococci at birth as a staphylococcus was grown from only one of 100 consecutive mothers swabbed from the vagina on commencing the final stages of labour (Table VII). These findings are in agreement with Wysham et al (1957a) 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 new-born.

Table XXXI was compiled from vaginal cultures taken in the maternity unit during the years 1958 and 1959. The swabs were taken from any woman with an abnormal discharge or vaginitis during pregnancy or with offensive lochia during the puerperium. The table also includes similar vaginal cultures taken from patients in the general hospital following an incomplete abortion in the early months of pregnancy. It can be seen that Staphylococcus aureus was the causative organism in only 2.1% of cases of vaginal infection in 186 pregnant or puerperal women. Of interest is the prevalence of Monilia albicans in cultures taken from abnormal discharges or vaginitis in pregnant women. This

organism, which was rarely seen in infection of the new-born, was present on culture in 32% of the 125 swabs taken (Table XXXI).

TABLE XXXI. CULTURES OF VAGINAL SWABS IN 1958 and 1959.

	SWABS TAKEN	NO GROWTH	S.AUREUS GROWN	MONILIA ALBICANS	B. COLI & OTHER ORGANISMS
Ante natal	125	55	3	40	27
Puerperal	61	27	1	1	32
Incomplete Abortion	100	51	7	3	39

STAPHYLOCOCCI IN THE LABOUR WARD.

The foregoing study of vaginal infection has lead me to the conclusion that the mother's vagina plays a very small part, if any, in the transmission of staphylococci in maternity hospitals and therefore staphylococci occurring in the "carrier state" on babies at birth and within the first 24 hours of life (Table XXXI) must be introduced from the environment of the maternity hospital or from its staff. Some of these staphylococci are undoubtedly airborne but others are most certainly introduced by direct contact from procedures carried out at birth (Table II). Many of the procedures such as tying the cord and removing mucous from the pharynx are unavoidable but others such as wiping the eyes are probably not only unnecessary but also dangerous.

EYE TOILET.

I am of the opinion that no form of eye toilet is justified, least of all the much beloved "one quick wipe" of the eyes with a moist "sterile" swab at birth. This custom has developed in Geelong over many years and has been extremely difficult to stop, particularly among

the older general practitioners and nursing sisters. The "spot check" carried out on the "sterile delivery trolleys" in the labour wards in July 1959 (p. 27) clearly showed the possibility of introducing staphylococci by wiping eyes even under "sterile" conditions.

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 showed that such eye toilets served no useful purpose in preventing "sticky eyes" but could amount to unnecessary and dangerous interference by producing minor trauma to the conjunctiva and eyelids and so possibly be the means of localizing staphylococci in the eye. TableXXXII shows the incidence of staphylococcal disease of the eyes occurring in infants on the individual floors of Baxter House during surveys carried out in October and November 1956 and March and April 1957.

TABLE XXXII. COMPARISON OF STAPHYLOCOCCAL DISEASE OF THE EYES ON INDIVIDUAL FLOORS OF BAXTER HOUSE.

FLOOR	INFANTS AT RISK	STICKY EYES
Ground	85	12.4%
First	71	12.7%
Second	83	13.2%
Third	71	4.9%
TOTAL	310	10.7%

The Third floor of Baxter House, during the period of the above surveys was in charge of an overpowering but extremely competent and dogmatic elderly sister who insisted that all eyes must be left alone unless "definitely infected." On all other floors routine eye toilets were carried out whether the eyes were "sticky" or not. Table XXXII

adds weight to a policy of avoiding procedures which are carried out on the baby as a routine rather than a necessity. Many of these may increase cross-infection in addition to adding a risk of minor trauma to epithelial surfaces and thereby providing a portal of entry or an area suitable for the localization of any staphylococci lodging in the eyes.

A policy of preventing routine eye toilets and stopping the instillation of prophylactic antibacterial drops or ointments into the eyes was started in the public patients in 1957 and has been almost universally accepted by the private practitioners. This measure was followed by a steady fall in the number of "sticky eyes" due to the staphylococcus (Table XXXIII). There has been no corresponding increase in the few "sticky eyes" caused by other organisms. The eyes in 1958, 1959 and 1960 were not touched unless for definite clinical reasons and then only on the order of a medical officer.

TABLE XXXIII. INCIDENCE OF "STICKY EYES" DUE TO STAPHYLOCOCCAL INFECTION. 1956 - 1960.

YEAR	STAPHYLOCOCCAL EYE DISEASE	
	INFANTS AT RISK	PERCENTAGE INFECTED
1956 (Three Months)	1298	12.4%
1957	2419	9.9%
1958	2323	6.8%
1959	2433	5.8%
1960 (Nine Months)	1928	2.8%

Hardyment, Wilson, Cockcroft and Johnson (1960) admit to chemical irritation by silver nitrate prophylaxis but consider there is insufficient evidence to justify the discontinuation or replacement of silver nitrate solution for prophylaxis against conjunctivitis. Their grounds for advising this measure is because they consider that after combating "clinical conjunctivitis" due to the staphylococcus their remaining problem was chiefly the prophylaxis of gonorrheal ophthalmia. These workers found two cases in 1724 babies who had no treatment to their eyes. There has been one case of gonorrheal ophthalmia in the past four years in Geelong and the gonococcus does not appear to be a real problem. If gonorrheal ophthalmia does occur it is easily combated and stands little chance of spreading to other babies when "rooming in" is practised.

"WOUND INFECTION" IN THE NEW-BORN.

I believe there is no fundamental difference between staphylococcal skin disease in the new-born and wound infection due to the staphylococcus in a surgical ward. The important predisposing factor is an injured epithelial surface and the initiating cause is the ubiquitous staphylococcus.

The ability of an organism to cause disease in a certain animal is its pathogenicity, which Rowley (1960) equates as being = virulence X (invasiveness and communicability) of the particular organism. The term "invasiveness and communicability" is used to include all those ill-defined characteristics of bacteria which are involved before the organism becomes established in the tissues and blood stream. In the case of the staphylococcus, very little is known of those characteristics and as it is most unlikely that the new-born can avoid contact with the staphylococcus (Tables II, IV and VI, Figure 6), it becomes doubly important not to develop a breach in the surface defenses of the host and so aid the factor of "invasiveness and communicability" of the

organism. Once the staphylococcus has made its primary lodgement in or on the tissue, the outcome - whether suppression or establishment into an established infection - depends on many poorly understood properties of both the host and parasite (Miles, Miles and Burke 1957).

A breach in any epithelial surface is an aid to the organism in its primary lodgement and there are many routine nursing procedures in a maternity hospital which may produce minute trauma and so a breach in the epithelium of the new-born. Such procedures are routine eye-toilets, regular weighing and frequent changing and bathing of the baby.

The above procedures are often habit and unnecessary for the welfare of the new-born. They are in addition usually potentially dangerous (Tables II and XXXII) and a reduction in their frequency is an easy and fundamental step in reducing the possibility of cross-infection by the staphylococcus.

FUNDAMENTAL MEASURES FOR REDUCING STAPHYLOCOCCAL DISEASE IN THE NEW-BORN.

The initial methods used for the control of staphylococcal disease in the new-born must be those which will reduce the possibilities of cross-infection by the staphylococcus, the importance of these would appear to be as follows.

1. The application of aseptic methods which entails the education of all staff in meticulous and careful technique together with understanding of the reasons for methods adopted and for techniques discarded. With understanding there comes full co-operation of all staff.
2. Dispersion of babies.
3. A review of routine nursing procedures to the baby and the avoidance of any handling proven to be unnecessary.
4. Constant vigilance by all staff in detecting any signs of staphylococcal disease in babies, mothers or other staff. A corollary to this requirement is a complete system of

recording the occurrence of staphylococcal disease and with it adequate bacteriological control.

5. The following are supplementary aids to the above fundamental measures -
   (a) Antibiotic control of staphylococcal infection.
   (b) Antiseptic methods of control of staphylococcal infection.

ANTIBIOTIC CONTROL OF THE STAPHYLOCOCCUS.

Some hospitals have approached the problem of minor staphylococcal disease in new-born by attempting to lower the nasal "carrier rate" in staff and babies by the routine application of an antibiotic nasal cream. An argument can be made for the use of antibiotic cream in the nose of infants and staff when combating temporary outbreaks of severer and more prevalent staphylococcal disease. It is possible, particularly in the baby, that the removal of one organism may well make the way clear for colonization of the nose by a more troublesome organism and the advisability of the constant use of these substances has been questioned (Rountree and Barbour 1951, Munro and Markham 1958). I am convinced that the use of antibiotics in the control of minor staphylococcal disease in the new-born is not warranted other than for a limited period during temporary outbreaks of more severe staphylococcal disease. No such outbreak occurred in Baxter House despite the prevalence of minor staphylococcal lesions.

It is well known that the indiscriminate removal of organisms from a host may have an adverse effect on the normal host - parasite balance and this may equally apply in the long range picture if there is poorly considered temporary removal of the staphylococcus in the new-born. There is a great difference between staphylococcal infection and staphylococcal disease (McDermott 1956), and it is particularly incumbent on us to view any present action or trend in the shadow of its effect on the future. This is constantly shown in the indiscriminate use of antibiotics.

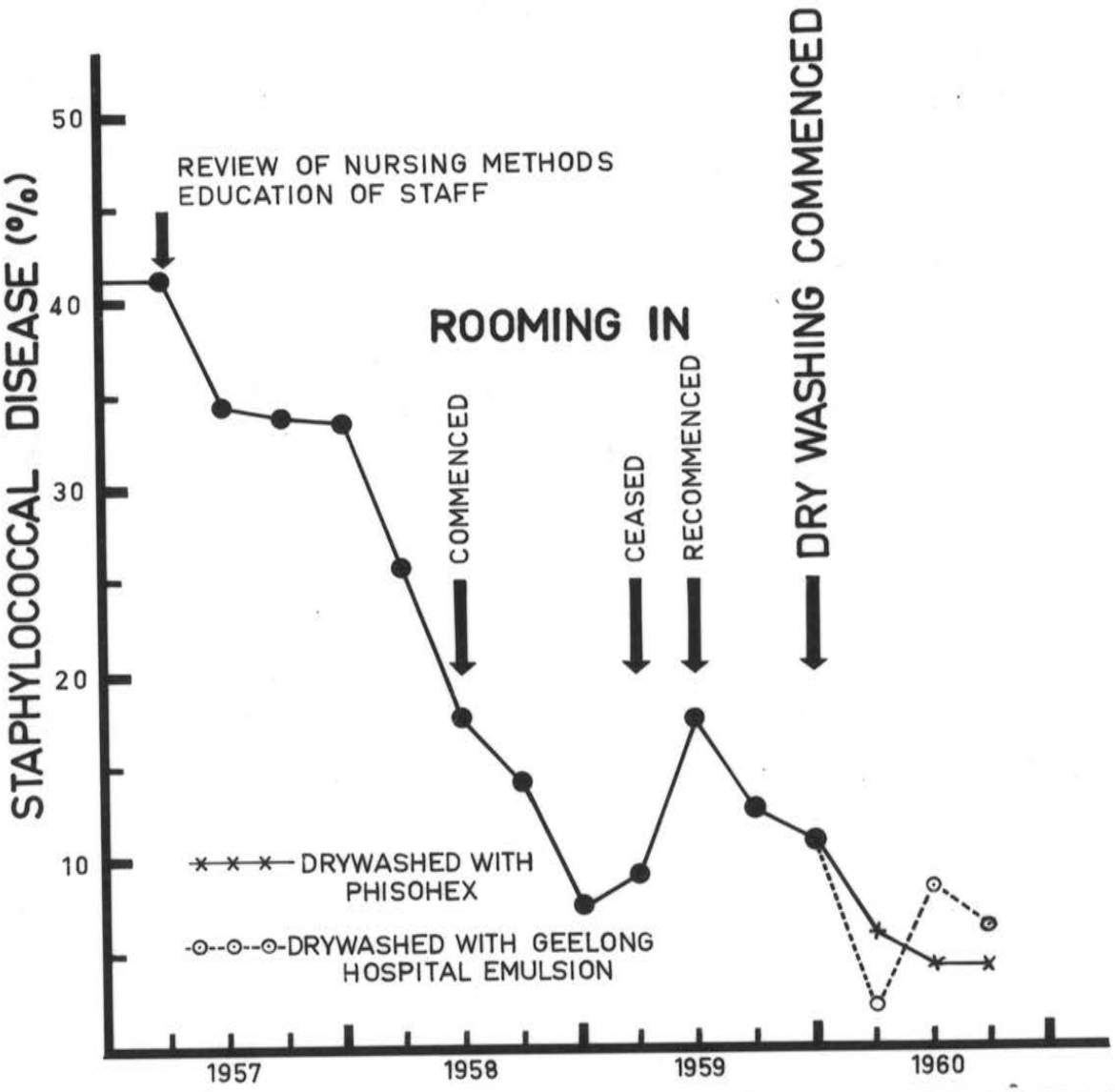

FIG. 11 INCIDENCE OF RECORDED STAPHYLOCOCCAL DISEASE IN NEW-BORN

The present position concerning the use of antibiotics is summarized in the report on "Staphylococcal Infections in Hospitals" by the Sub-Committee of the Central Health Services Council Standing Medical Advisory Committee (1959). "Experience has shown that the continued use of any antibiotic in a hospital community is accompanied by the emergence of staphylococcal strains against which the drug in question is powerless to act..... Drug resistance would be serious enough if it resulted only in failure to suppress staphylococcal disease. There is evidence, however, that morbidity from staphylococcal infection may even be enhanced by the use of antibiotics."

ANTISEPSIS AND THE NEW-BORN.

The use of antiseptic substances applied 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 new-born. The substances which have received most attention are hexachlorophene and chlorhexidine, used either in solution or emulsion (Hardyment 1954, Wysham et al 1957a, Hill et al 1959) or in a dusting powder (Gillespie et al 1958, Green 1959, Corner, Crowther and Eades 1960).

Kossiakoff (1887) was well aware of "the properties which microbes possess to adapt themselves to antiseptic environments" and the use of antiseptic substances in the control of staphylococcal disease in the new-born must always be stressed as an ancillary aid in the overall problem and not even a part answer by itself. If staff handling new-born babies do not appreciate this limitation in regard to antiseptic substances, the first principles regarding aseptic technique will be as readily clouded in a "protective antiseptic umbrella" as they were in a "protective antibiotic cover."

In 1960 a method of "dry washing" babies (Hill et al 1959) was introduced into the routine of Baxter House. Two different emulsions were used and the use of both resulted in a definite reduction in the overall incidence of minor staphylococcal disease. A slight rise from

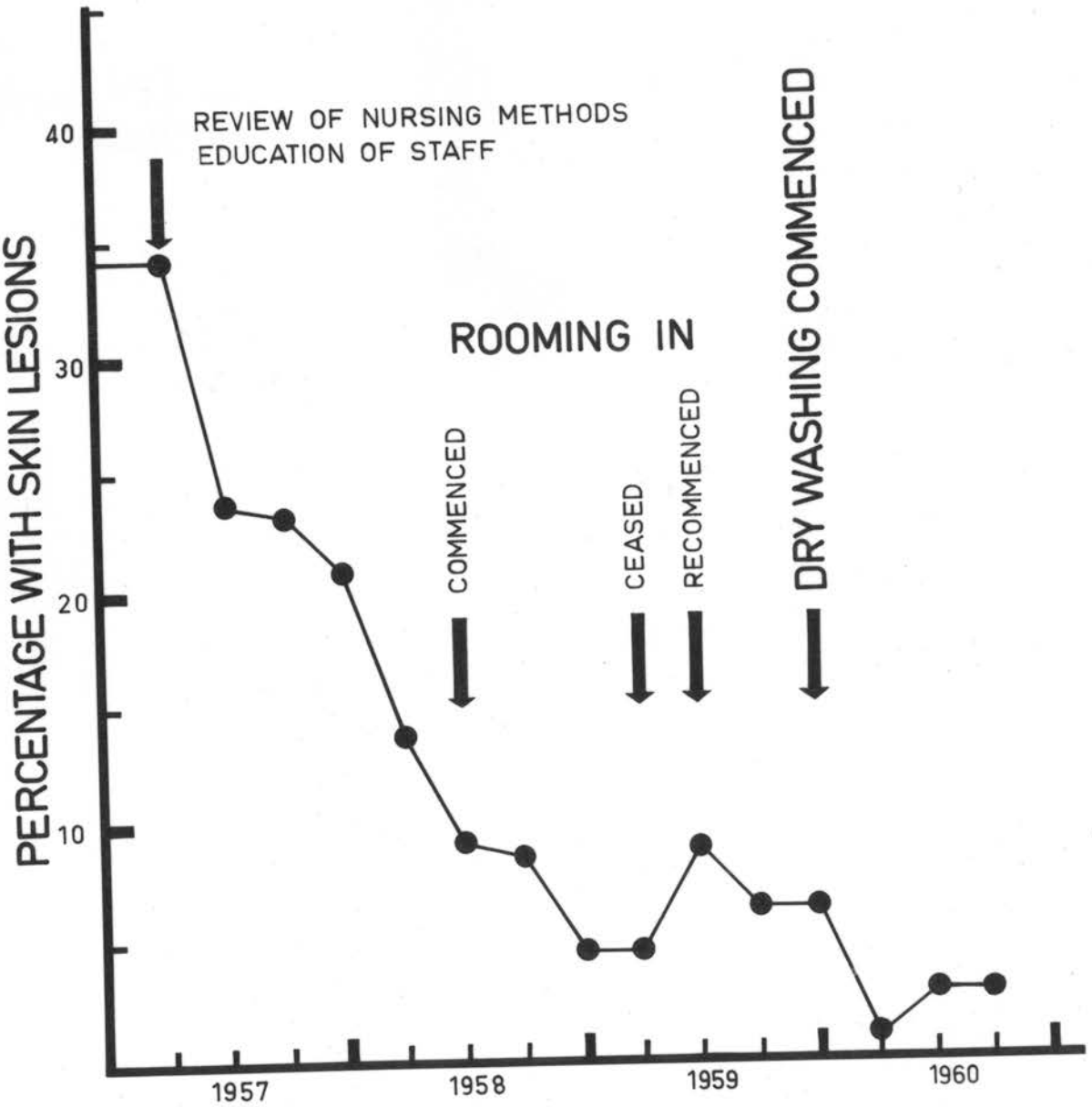

FIG.12 INCIDENCE OF STAPHYLOCOCCAL SKIN DISEASE IN NEW-BORN

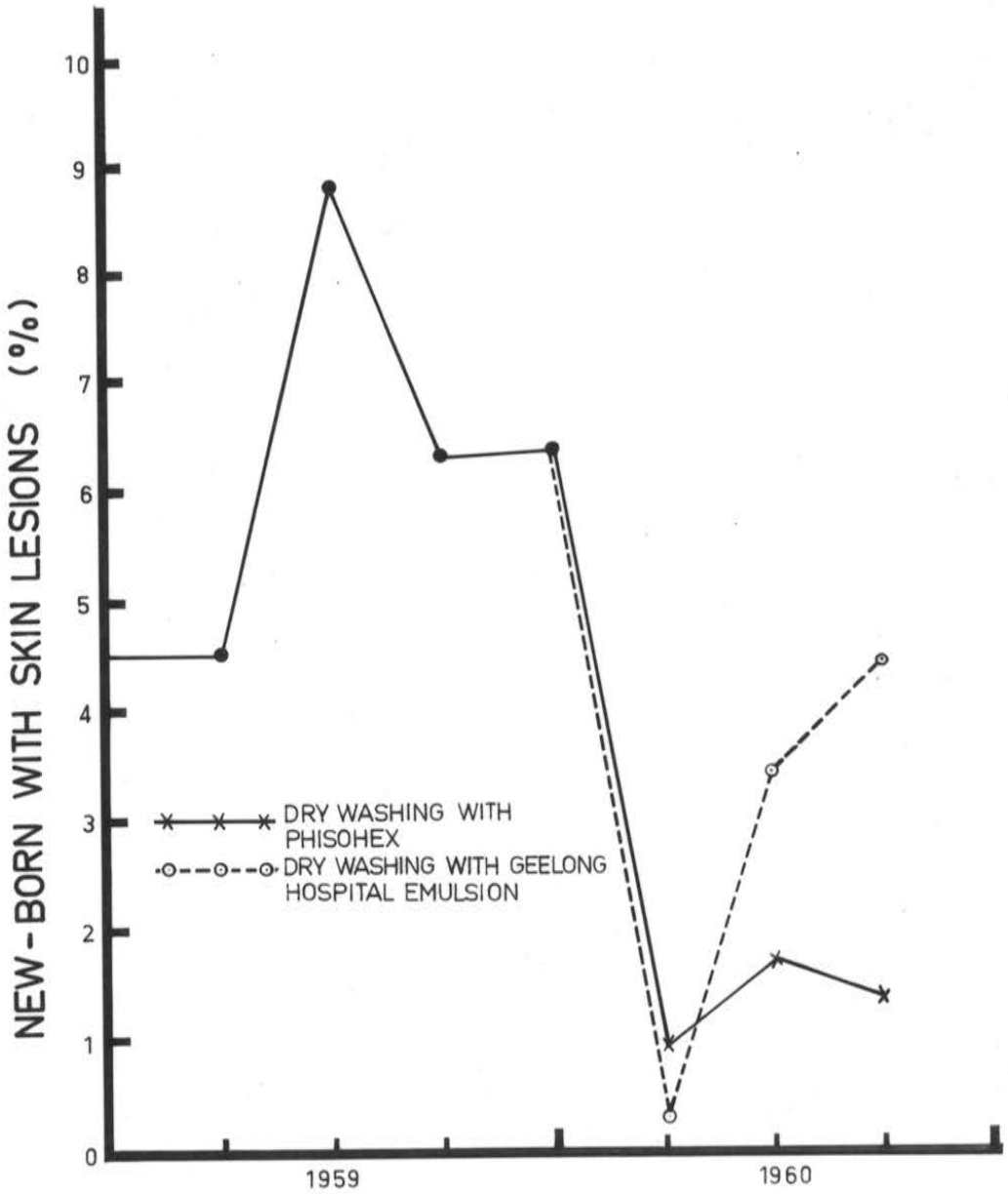

FIG. 13 INCIDENCE OF SKIN LESIONS RELATED TO TYPE OF EMULSION USED

this low incidence occurred in the winter months (Table X and Figure 11). The lowered incidence of minor staphylococcal disease in the new-born with "dry washing" is further emphasized when the incidence of skin lesions occurring in 1960 is compared with that of the preceding three years (Figure 12). It was considered that possibly the lanolin and wax in the Geelong Hospital Emulsion was as an effective defensive barrier to the lodgement of bacteria as the antiseptic layer of hexachlorophene in phisohex. This latter barrier is considered by some workers as illusory and readily destroyed by organic matter such as serum or blood (Göpel, Rücker and Schütz 1958, Kinsella 1959). Other workers disagree with this view and consider that a film of hexachlorophene emulsion, particularly if repeatedly applied to the skin, is a useful and effective antiseptic barrier (Boheimer 1959, Smylie, Webster and Bruce 1959).

It was decided to use both emulsions on unselected babies in Baxter House in 1960 in an attempt to evaluate the relative effectiveness of an antiseptic barrier on the skin compared with a coating of a protective fatty layer (cf. vernix caseosa). I was of the opinion that the latter might prove as effective as the antiseptic barrier.

A comparison of the relative effectiveness of the two emulsions is shown in Figures 11 and 13. These figures show that the hexachlorophene was important to the technique of "dry washing" in its effectiveness in decreasing staphylococcal disease, and in particular, staphylococcal skin lesions.

The value of hexachlorophene was further exemplified when considering the effectiveness of "dry washing" on the infant "carrier rates" of the staphylococcus and Figure 14 compares those of 1959 with that of 1960. It shows the following infant "carrier rates" by the 4th day of life.

1959 (No full bathing of babies).	90% of babies.
1960 (Geelong Hospital Emulsion).	73% of babies.
1960 (Phisohex).	41% of babies.

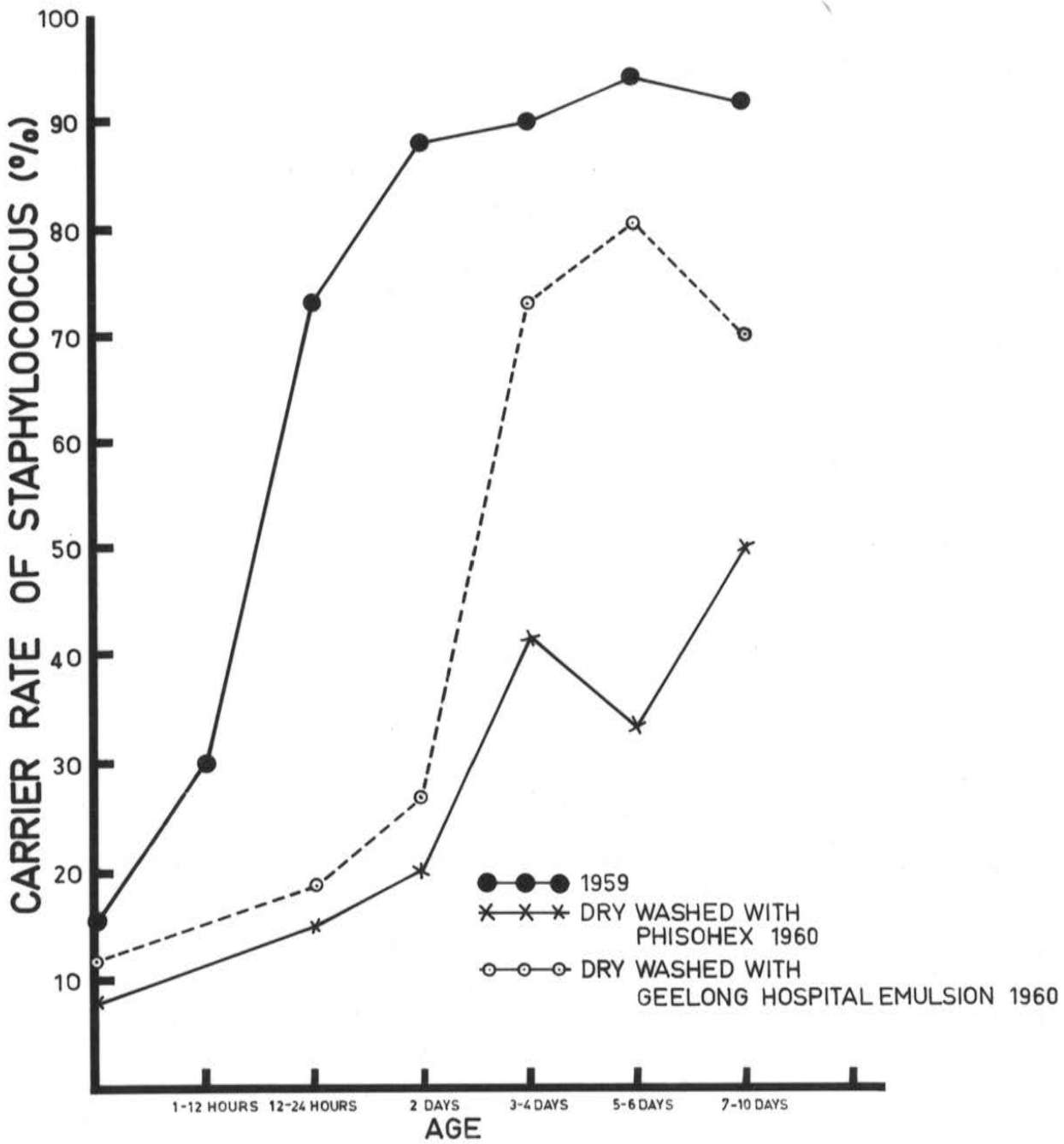

FIG. 14 COMPARISON OF INFANT CARRIER RATES 1959 & 1960

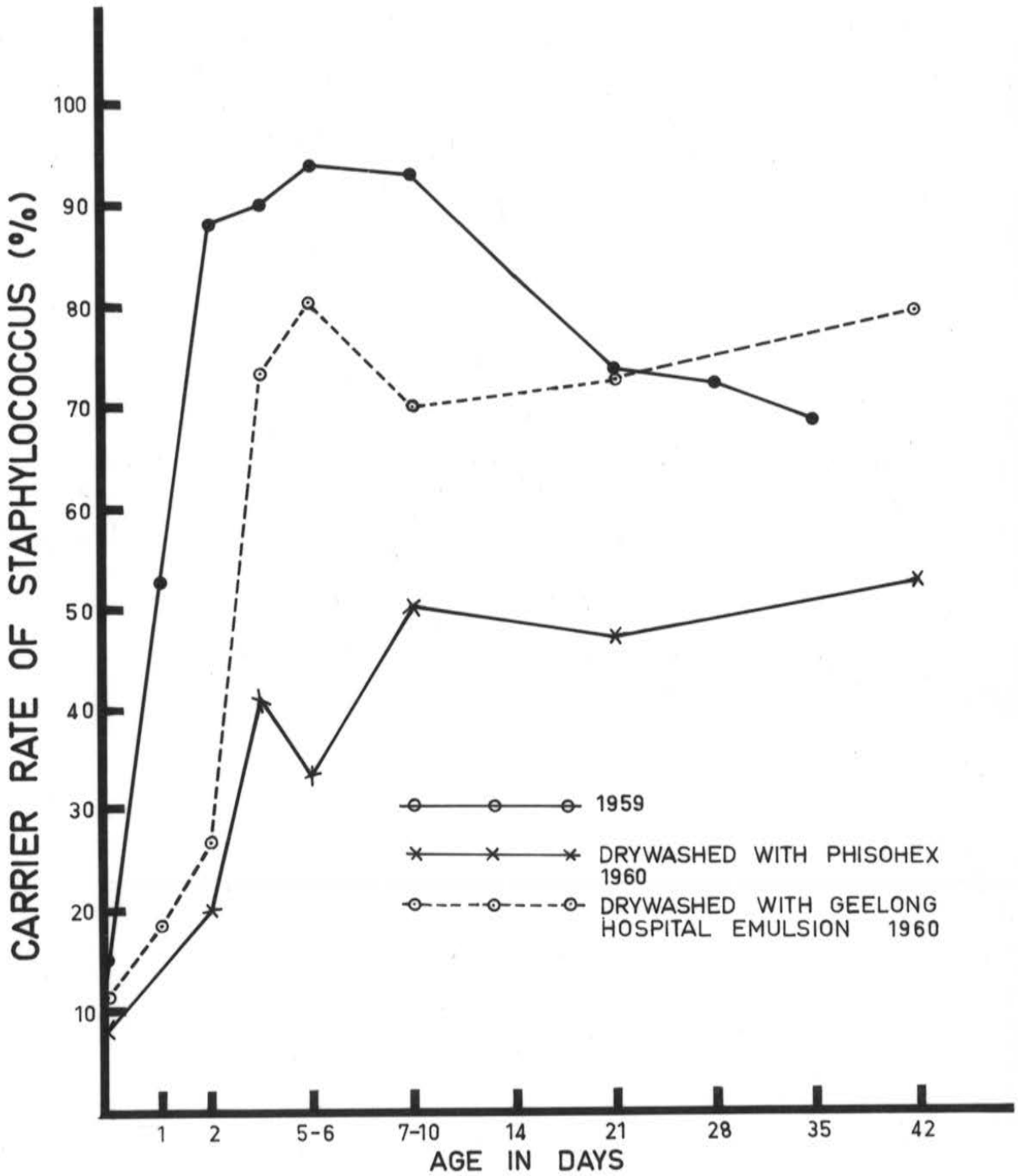

FIG. 15 INFANT CARRIER RATE IN HOSPITAL & AT HOME 1959 & 1960

A similar lowered "carrier rate" among the babies "dry washed" with phisohex when in hospital was also shown to be maintained for at least four to five weeks after discharge from hospital (Figure 15 and Tables XIV and XV).

I believe the use of an "antiseptic umbrella" to lower the infant "carrier rate" is a useful complementary aid in the prevention of staphylococcal disease in the new-born when asepsis is good and under normal conditions (Tables XI and XII) and could 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. Even in these conditions it still must be stressed as complementary to the first principles of asepsis.

STAPHYLOCOCCAL INFECTION AND THE HOME.

Tables V, XIV and XV include 57 infants swabbed at home from the eyes, nose and umbilicus for periods up to five and six weeks after birth. This "carrier rate" is compared in Table XXXIV in three categories depending on the nursing methods used. It can be seen that the infants "dry washed" with phisohex maintained the lowest "carrier rate".

TABLE XXXIV. INFANT "CARRIER RATE" FOLLOWING DISCHARGE FROM HOSPITAL. 19 INFANTS IN EACH CATEGORY.

YEAR	AGE OF BABY	PERCENTAGE OF POSITIVE SWABS	
		EYES, UMBILICUS OR NOSE	NOSE ONLY
1959	3 wks	73.7%	52.6%
	5 wks	68.4%	52.6%
1960 (Phisohex)	3 wks	47.4%	42.1%
	6 wks	52.6%	42.1%
1960 (Geelong Hospital Emulsn)	3 wks	73.7%	47.4%
	6 wks	78.9%	73.7%

The maintenance of a low "carrier rate" in the first few months of life is considered desirable by many workers as a feature of the epidemiology of many nursery outbreaks has been the number of infants who develop the first signs of staphylococcal disease following their discharge from hospital (Colbeck 1949, Shaffer, Sylvester, Baldwin and Rheins 1957, The National Conference on Hospital-Acquired Staphylococcal Disease 1958, Wentworth, Miller and Wentworth 1958a). It is thought that newly born infants carrying the staphylococcus home from maternity hospitals may act as a focus for an increase in the level of community acquired staphylococcal disease (Wentworth et al 1958b, Hurst and Grossman 1960).

The 57 babies swabbed at home were examined also for signs of staphylococcal disease (Table XXXV.) and these examinations showed that the morbidity from staphylococcal disease in infants after discharge from hospital appeared to bear a relationship to the "carrier rate".

TABLE XXXV. PERCENTAGE OF INFANTS UP TO 6 WEEKS OF AGE DEVELOPING STAPHYLOCOCCAL LESIONS AT HOME.

YEAR	"CARRIER RATE" AT SIX WEEKS	PERCENTAGE OF INFANTS WITH LESIONS	COMMENTS
1959	68.4%	10.5%	The mother of another infant had a breast abscess.
1960 (Phisohex)	52.6%	5.2%	One child with Proteus infection of the buttocks.
1960 Geelong Hospital Emulsion	78.9%	26.3%	One family with multiple staphylococcal skin lesions in three other children.

Despite the occurrence of further minor outbreaks of staphylococcal disease in infants when discharged from hospital, the subsequent occurrence of severe staphylococcal disease has never been common (Table XXVI) and only 0.30% of 10,401 infants delivered were re-admitted to hospital as a result of staphylococcal disease in the first six months of life. A comparison of Table XXVI with Figure 11 shows that even this low incidence significantly varied and bore a direct relationship to the prevalence of staphylococcal disease in the new-born. It can be seen in this comparison that 0.46% of babies were re-admitted in 1956 - 57, whereas in 1958 - 59 only 0.29% were re-admitted. In the first nine months of 1960 no infant was re-admitted to hospital as a result of staphylococcal infection.

The number of deaths due to staphylococcaldisease in the first six months of life similarly varied with the prevalence of staphylococcal disease in the new-born, (Figure 11 and Table XXVI).

There is no doubt that when staphylococci were prevalent in Baxter House, the subsequent progress of infants on discharge home was adversely affected. Measures taken to reduce staphylococcal disease in hospital were only fully reflected in the reduced morbidity due to the staphylococcus after the infant had been discharged home.

There are several answers to most clinical problems and it would appear that dusting the baby with a powder containing hexachlorophene or chlorhexidine (Corner, Crowther and Eades 1960) would reduce the morbidity due to the staphylococcus as effectively as "dry washing" with phisohex. It is possible that decreasing the length of stay in hospital of the baby would be similarly effective.

The Bradford Experiment (Theobald 1959), in which normal pregnancies were sent home on the second day, may well be as useful in preventing "the baby becoming a culture medium for the staphylococcus" as the experiment was in improving antenatal care and almost eliminating severe pregnancy toxemia.

THE STAPHYLOCOCCUS ITSELF.

A review of the accumulated knowledge concerning "The Staphylococci Pathogenic for Man" was made by Professor J.W. Bigger in 1937 and 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. The relative importance of the factors directly related to the host and to the parasite is still in doubt and "in spite of the vast efforts to probe into the pathogenesis of staphylococcal infections we are still ignorant of many of the basic facts" (Elek 1959).

Not only is there no known method of effectively protecting humans against staphylococcal disease, but also no satisfactory way of correctly assessing the relative pathogenicity to man of the numerous strains of staphylococci. In the majority of cases staphylococcal disease does not follow staphylococcal infection and this is so even wher we are dealing with a strain isolated from a severe or fatal lesion and so of proven potential pathogenicity to man. I am convinced from the results of the surveys in Baxter House, that in Geelong at least, the circumstances of the infection played a much more important part in the production of staphylococcal disease in the new-born than any factor directly related to the ubiquitous staphylococcus itself (Plueckhahn and Banks 1958).

Reverting to the organism itself - the factor of virulence is not absolute and may refer to a variety of attributes for different organisms and conditions. I consider the virulence of a particular strain of staphylococcus for a newly born child is the ability of that organism to establish infection and multiply in the infant. There is no laboratory test whereby this can be adequately assessed and although animal pathogenicity tests as described by Selbie and Simon (1952) do give some indication of α haemolysin, fibrinolysin and coagulase production of a particular organism, there is always

that "elusive something else" when an attempt is made to relate the tests to man (Parish and Cannon 1960). The "in vitro" test for coagulase production is the generally accepted criterion of staphylococci as to their potential pathogenicity. At the most, it is only a very rough guide and does not distinguish the more virulent from the less virulent organisms if these exist among the coagulase positive staphylococci.

Elek (1956), and Elek and Conen (1957) showed by human experiment that there appears to be no gross differences in virulence to human beings between the various coagulase positive strains of Staphylococcus aureus. This opinion appears to be confirmed by the results of the present survey of staphylococcal disease as seen among the new-born in Geelong.

The results of phage typing of coagulase positive staphylococci isolated from lesions in infants in Baxter House show a scatter of the staphylococci over all phage groups (Table XX). There is a similar scatter when the phage patterns of the staphylococci present in the "harmless" carrier state are compared with those causing lesions (Table XXI). These findings are contrary to the experience of R.E.O. Williams (1959), who as a result of a review of the published records of 32 epidemics of staphylococcal infection in maternity hospitals and 15 in surgical wards stated "The phage typing results show clearly that differences between staphylococci do exist". Other workers (Barber and Burston 1955, Gillespie, Simpson and Tozer 1958, and Barber 1960) agree with Williams and consider there is a "striking" difference in the distribution of strains isolated in maternity units and surgical wards. These authors 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 units.

The present study of staphylococcal disease in Geelong differs from the above findings in that of 230 strains of staphylococci

from lesions in the new-born in Baxter House, 13.9% were of phage group I and 20.0% were of phage group III (Table XXI). Similarly in the general wards the reverse also applied and 28.6% of 196 strains were phage group I and only 9.7% were phage group III (Table XXV).

Many workers in Australia and overseas have credited staphylococci of phage pattern 80/81 with a higher degree of virulence for the new-born than staphylococci in general (Rountree and Freeman 1955, Gillespie and Alder 1957, Monro and Markham 1958, Williams 1959, and Barber 1960). This was notapparent in Baxter House in 1959 and 1960 when staphylococci of phage pattern 80/81 did not predominate in cases of staphylococcal disease of the new-born (Table XXIII), and in addition showed no special predilection to establish specific types of lesions in the new-born (Table XXXVI).

TABLE XXXVI. PHAGE PATTERN AND TYPE OF STAPHYLOCOCCAL LESIONS SEEN IN THE NEW-BORN IN 1959 AND 1960.

TYPE OF LESION	PHAGE PATTERN		
	80/81	OTHER GROUPS	NON-TYPABLE
Pustules & Paronychiae	5	14	50
"Sticky Eyes"	8	40	63
Infected Umbilicus	2	2	8
TOTAL	15	56	121

The high proportion of non-typable strains lessens the value of phage typing when used in studying the transmission of the staphylococcus in Geelong. This does not apply when assessing the relative importance or virulence of phage pattern 80/81 in causing disease in the new-born. If this phage pattern did possess greater virulence than other staphylococci for the new-born one would expect it to occur more frequently in lesions than in the "carrier state". A study of

Table XXI shows this was not so in Geelong where staphylococci of phage pattern 80/81 were found in 13.5% of the staphylococci isolated in infant "carrier rate" surveys and in only 8.7% of the staphylococci isolated from lesions. It would also appear in Geelong that staphylococci of phage pattern 80/81 have a greater virulence for adults than for the new-born as 26.0% of 196 strains isolated in the general wards of the Geelong and District Hospital were of phage pattern 80/81 (Table XXV). Also the staphylococcal lesions due to phage pattern 80/81 occurring in the general wards appeared to have a greater tendency for localization and pus formation than those found in the new-born (Tables XXXVI and XXXVII). This is further evidence of the apparently dominant role played by the host in staphylococcal disease in the new-born.

TABLE XXXVII. RELATION OF PHAGE PATTERN 80/81 TO TYPES OF LESIONS SEEN IN ADULTS AND INFANTS. 1959 - 1960.

TYPE OF LESION	PHAGE PATTERN		
	80/81	OTHER GROUPS	NON-TYPABLE
Pustules & Paronychiae (Baxter House)	5	14	50
Boils & paronychiae (General Wards)	17	1	9
Abscesses (General Wards)	12	1	1
Wound Infection (General Wards)	6	2	14
Pneumonia (General Wards)	10	2	8
Breast Abscess (Mothers)	5	1	3

In this study it has not been possible to implicate a particular phage type of staphylococcus with the prevalence of staphylococcal disease in the new-born in Geelong and the high incidence of infant staphylococcal disease appears to be more intimately associated with factors unrelated to the virulence of the strains of staphylococci isolated.

Other principal factors directly related to the organism in its ability to establish disease in a host may be any or all of the following.

(a) Size of bacterial invasion.

(b) Portal of entry.

(c) Synergism and antagonism existing amongst certain bacterial species.

The critical number of staphylococci necessary to produce disease in the normal newly born infant appears to be large but the factors of "invasiveness and communicability" does increase when staphylococci are numerous (Figures 11, 12 and 14). 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" resulted in a decreased incidence of staphylococcal disease in the new-born. Manfield, Shooter and Lidwell (1960) found that staphylococcal sepsis occurred three times more often in babies found to be carriers than in those who were not.

I believe that the prevalence and thus the number of available viable staphylococci exerts an important influence on properties of "invasiveness and communicability" as seen in the staphylococcus. The increase in number of staphylococci does not necessarily need to be a general increase related to abundant means of transmission (Figure 6) but also may be due to a local increase on the host itself as a result of a favourable portal of entry caused by any breach in the continuity of an epithelial surface such as a chaffed skin, moist umbilicus or scratched conjunctiva. These areas are not only a better soil than an intact epithelial surface for the multiplication

of any staphylococci present, but also aid localization of the organism.

In speaking of wound infection, Williams (1959) said "If small numbers of cocci can infect, why does infection not happen more often, since small numbers of staphylococci must fall into the wounds at operation? Much, perhaps most of the explanation must lie in the resistance of tissues". I am convinced that the latter is true in the new-born and depends largely on non-specific cellular and humoral factors of which virtually nothing is known.

The factor of bacterial antagonism and synergism plays a prominant part in certain bacterial and fungal diseases. The suppression of one species by another is well known and it was considered at one stage that the methods used to control staphylococcal disease in the new-born in Baxter House may be accompanied by an increase due to other organisms such as Bacterium coli, Proteus vulgaris, Pseudomonas pyocyaneus and others. This was not so and the incidence of disease due to such organisms has remained fairly constant over the past four years (Table XXXVIII).

TABLE XXXVIII. INCIDENCE IN NEW-BORN OF BACTERIAL DISEASE OTHER THAN STAPHYLOCOCCAL. 1956 - 1960.

YEAR	INFANTS AT RISK	BACTERIAL DISEASE OTHER THAN STAPHYLOCOCCAL
1956		
October - December	640	3.0%
1957		
January - June	1149	4.8%
July - December	1270	4.7%
1958		
January - June	1117	3.3%
July - December	1206	1.9%
1959		
January - June	1153	3.7%
July - December	1240	2.6%
1960		
January - June	1257	2.7%

The handling of the problem of the staphylococcus and the new-born must be considered in the light or shadow of its effect on the future and little is known concerning the immunological pattern and responses of man to infection by the staphylococcus, which organism will remain abundantly present in the community even if eliminated from our maternity hospitals. It does appear that there are methods available which will greatly reduce if not eliminate the number of viable staphylococci on the surfaces of the new-born. The use of these methods must be assessed with the possibility of a temporary elimination of the staphylococcus from the surfaces of the new-born delaying the development of immunological responses to this organism and resulting in the exposure of the infant to the ubiquitous staphylococcus in later life as a new hazard and possibly a more dangerous agent than in the first few weeks of life.

Finally, I am convinced that factors related to the host are more important than those directly related to the organism and the mere presence of a moderate number of viable staphylococci on the normal newly born infant is not harmful and may even be desirable. Of greater immediate need for maternity hospitals is not the temporary elimination of the staphylococcus from the surfaces of the new-born but a better understanding of its means of attack and a more intimate and accurate knowledge of the methods of its transfer to the surfaces of the new-born.

IX. SUMMARY.

> "The reported epidemics of staphylococcal infection are the simpler ones, and there is great need for detailed analysis of the more complex situations, which seem also to be the commoner.
>
> R.E.O. Williams, LONDON (1959).

This thesis is a bacteriological and clinical survey of infection due to Staphylococcus aureus as seen in a 95 bed maternity hospital and concerns 10,401 infants born between July 1st, 1956 and September 30th, 1960.

The survey was directly responsible for the introduction of various changes in the conduct of the hospital during the survey with a resultant reduction in the overall incidence of minor staphylococcal disease in the new-born from 41.0% to 5.1%. Staphylococcal skin disease was similarly reduced from 30.8% to 2.1%, and staphylococcal eye disease from 12.4% to 2.8%.

The three principal changes responsible for this reduction in incidence of minor staphylococcal disease in the new-born were restriction of routine nursing procedures shown to be unnecessary for the baby, the introduction of "rooming in", and a method of "dry washing" infants with hexachlorophene emulsion. All changes in the conduct of the maternity wing were introduced in stages which were accompanied by strict bacteriological control. This was followed by an assessment of the effect of the changes on the incidence of minor staphylococcal disease in the new-born, and on the "carrier rates" of infants, mothers and staff.

All infants were followed for six months after birth. 0.30% were readmitted to hospital as a direct result of staphylococcal disease. 0.077% died from staphylococcal disease. Both this morbidity and mortality is shown to bear a direct relationship to the frequency of minor staphylococcal disease in the new-born.

The incidence of breast abscess in 9,291 mothers was 1.16%. This incidence was also related to the frequency of minor staphylococcal disease in the new-born and was reduced from 2.5% in 1956 to 0.60% in 1960.

Antibiotic sensitivity and phage patterns of staphylococci isolated are used in the survey in studying the epidemiology of staphylococcal disease in the new-born.

Phage pattern 80/81 and the part it plays in staphylococcal infection in the new-born is discussed. Staphylococci of this phage pattern did not play a dominant role in staphylococcal infection in Baxter House - this is contrary to reports from elsewhere in Australia and overseas.

The virulence of the staphylococcus itself is shown to be less important than the circumstances of the infection.

Hexachlorophene emulsion is shown to play a definite part in the reduction of staphylococcal disease and infection in infants both in the maternity wing and in the first four weeks at home.

The complete survey emphasizes the great gaps in our knowledge of the actual modes of transmission of the staphylococcus, its means of attack and factors effecting the reactions of the host in defence.

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Dr. Hildred Butler, Bacteriologist of the Royal Women's Hospital, Melbourne, performed most of the phage typing.

The survey would not have been possible without the wholehearted support of the medical practitioners in Geelong and surrounding district. All fully co-operated and allowed complete access to both private and public patients and their records.

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