# Frequency of Hemolytic Streptococci in the Throats of Well Children in Dallas

ROBERT M. PIKE, PH.D., AND GLADYS J. FASHENA, M.D.

*Departments of Bacteriology and Immunology, Pediatrics, and Pathology, Southwestern Medical College, Dallas, Tex.*

THE general observation that hemolytic streptococcus infections become less prevalent as one approaches the tropics is supported by the available scarlet fever morbidity data for various countries as compiled by Schwentker, Janney, and Gordon.[1] Even within the United States, the incidence of scarlet fever shows an association with latitude.[2] The combined morbidity rate in 1944 for the states of Washington, Wisconsin, and New York was 177 per 100,000 population while that of Louisiana, Alabama, and Florida was 24. The rate for Texas was 58. On the other hand, there is evidence to show that scarlet fever [3, 4] and rheumatic fever [5] mortality is as high in Texas as in some of the northern states.

The carrier rate for group A hemolytic streptococci has been found to be related to the incidence of scarlet fever,[1, 6–8] rheumatic fever,[8, 9] and certain upper respiratory infections.[8, 10, 11] Although marked differences in the geographic distribution of hemolytic streptococci have been found in Army installations,[8] it is not clear how closely the carrier rate is associated with latitude. In view of these facts it appears that knowledge concerning the incidence of hemolytic streptococci, particularly serological group A, in the throats of well children in the southwestern part of the United States would be a useful addition to the general picture of the distribution of these organisms and their relation to disease.

## METHODS

The subjects chosen for the study were children appearing at the venereal disease and dental clinics of the Freeman Memorial Clinic, Dallas. All were well at the time specimens from the throat were obtained, and particular care was taken to avoid individuals with even minor upper respiratory infections. The group included white, colored, and Mexican children in the proportion of 47, 44, and 9 per cent, respectively. A total of 900 swabbings from 756 children under the age of 15 were examined over a period of 13 months.

All throats were swabbed by one of us. Swabs were applied to the posterior nasopharynx as well as to the tonsillar area, and specimens were cultured within one hour by the methods summarized in Table 1. The details of methods 1 to 6 have previously been described.[12–15] Beef heart infusion agar and broth were used throughout the entire study. All except the first 166 specimens were examined by preliminary incubation of swabs in sodium azide-crystal violet blood broth, followed by plating on beef heart infusion agar containing 5 per cent human blood (method 3), thereby providing a basis for observing any pos-

TABLE 1

*Summary of Results Obtained in Culturing 900 Throat Swabbings from Normal Children by Various Methods*

| Number of Swabbings | Per cent of Cultures Positive for Hemolytic Streptococci by Various Methods * | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | | Combined | |
| | Gross | A | Gross | A | Gross | A | Gross | A | Gross | A | Gross | A | Gross | A | Gross | A | Gross | A |
| 166 | 13.3 | 4.5 | 31.9 | 16.3 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 33.1 | 18.1 |
| 18 | 16.7 | 5.6 | 38.9 | 22.2 | 38.9 | 22.2 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 38.9 | 22.2 |
| 40 | .. | .. | 37.5 | 17.5 | 47.5 | 25.0 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 50.0 | 25.0 |
| 159 | .. | .. | 32.1 | 11.9 | 39.0 | 17.0 | 41.5 | 16.4 | .. | .. | .. | .. | .. | .. | .. | .. | 42.8 | 17.6 |
| 9 | .. | .. | .. | .. | 55.6 | 55.6 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 55.6 | 55.6 |
| 85 | .. | .. | .. | .. | 45.9 | 25.9 | .. | .. | 45.9 | 27.1 | .. | .. | .. | .. | .. | .. | 50.6 | 30.6 |
| 90 | .. | .. | .. | .. | 54.4 | 31.1 | .. | .. | 40.0 | 24.4 | 14.4 | 10.0 | .. | .. | .. | .. | 54.4 | 31.1 |
| 178 | .. | .. | .. | .. | 39.3 | 25.8 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 39.3 | 25.8 |
| 81 | .. | .. | .. | .. | 42.0 | 29.6 | .. | .. | .. | .. | 12.3 | 8.6 | 19.8 | 12.3 | 13.6 | 8.6 | 43.2 | 30.9 |
| 74 | .. | .. | .. | .. | 37.8 | 25.7 | .. | .. | .. | .. | 17.6 | 13.5 | 14.9 | 10.8 | .. | .. | 37.8 | 25.7 |
| Total 900 | 13.6 | 4.9 | 32.9 | 20.1 | 42.6 | 25.2 | 41.5 | 16.4 | 41.9 | 25.7 | 14.7 | 10.6 | 17.4 | 11.6 | 13.6 | 8.6 | 42.2 | 24.6 |

* 1. Plated directly on rabbit blood agar
2. Plated on rabbit blood agar after incubation in sodium azide-crystal violet broth
3. Plated on human blood agar after incubation as in 2
4. Plated on human blood streaked-poured plates after incubation as in 2
5. Plated on human blood agar after incubation in potassium tellurite-crystal violet broth
6. Suspended in broth and plated directly on human blood agar
7. As in 6 but incubated anaerobically
8. Plated directly on human blood streaked-poured plates containing sodium azide and crystal violet

sible seasonal variation in the carrier rate.

The last 155 throat swabs were also cultured anaerobically (method 7). Each swab was placed in 2 ml. of sodium azide-crystal violet broth and agitated to suspend the bacteria. Immediately, each of two human blood agar plates was streaked with a large loopful of the suspension. One plate was incubated anaerobically and one aerobically (method 6). The swab was then incubated in the broth for about 24 hours and a third plate streaked (method 3). The results shown in Table 1 are essentially the same for aerobic and anaerobic direct platings.

In method 8, Table 1, the inhibiting substances were added to the plating medium. Although alpha and beta hemolysis by surface growth is not typical on blood agar containing sodium azide,[13] preliminary experiments suggested that deep colonies could be recognized more readily than surface colonies. Therefore streaked-poured plates were prepared as previously described [14] except that agar containing sodium azide 1 in 15,000 and crystal violet 1 in 500,000 was used. Although Gram-

TABLE 2

*Increase in Carrier Rates with Repeated Swabbings*

| Swabbings | Number of Individuals | Carrier Rates Based on All Swabbings | |
|---|---|---|---|
| | | Gross Per cent | Group A Per cent |
| 1st | 756 | 47.4 | 26.3 |
| 1st and 2nd | 110 | 61.8 | 35.5 |
| 1st, 2nd, and 3rd | 22 | 72.7 | 45.5 |
| 1st, 2nd, 3rd, and 4th | 11 | 81.8 | 45.5 |
| 1st, 2nd, 3rd, 4th, and 5th | 1 | 100.0 | 0 |

negative organisms and staphylococci were satisfactorily inhibited, fewer hemolytic streptococci were isolated from these plates than from ordinary streaked blood agar plates.

Colonies suspected of being beta hemolytic streptococci were fished to sections of blood agar plates. One colony was fished from each plate unless the appearance suggested more than one kind of hemolytic streptococcus. Those subcultures which were confirmed as hemolytic streptococci were transferred to glucose infusion broth for serologic grouping, using antigens prepared by the formamide extraction method. Both hemolytic and nonhemolytic group D streptococci were found, but only the beta hemolytic strains are recorded in the protocols.

## RESULTS

The percentage of specimens from which hemolytic streptococci were isolated by all methods combined is shown in the last column of Table 1. The gross carrier rate for the 900 throat specimens was 42.2 per cent and the rate for group A alone was 24.6 per cent. There was very little difference between the rates obtained by combined methods and those obtained by using enrichment broth alone (method 3).

Throats of 110 of the 756 children examined were cultured more than once. Table 2 shows the increase in the proportion of individuals found to harbor hemolytic streptococci as the number of examinations increased. Both the gross and group A rates as obtained by one swabbing were nearly doubled by three additional examinations.

For the purpose of observing any possible seasonal variation in the incidence of hemolytic streptococci, carrier rates were determined for each fifty consecutive swabbings (Table 3). These rates are based on sodium azide-crystal violet enrichment broth cultures all of which were plated on human blood agar except the first sixteen which were plated on rabbit blood agar. According to previous experience the use of rabbit blood would tend to lower the rate slightly.[14] In Figure 1 the rates are plotted against time and are shown in relation to the number of cases of scarlet fever reported each week in Dallas County. Except for three low group A rates in July and August, the seasonal variation is not marked.* When the lowest (14 per cent) and the highest (36 per cent) group A rates are compared, however, the difference appears to be significant ($P=0.01$). The abrupt rise in the carrier rates in September following the low points in July and August suggests that the change was not due to any seasonal factor because there was no comparable meteorological change in September. The carrier rates for hemolytic streptococci of groups other than A varied from month to month without any suggestion of a seasonal trend. In contrast to the streptococcus carrier rates, the distribution of reported scarlet fever cases in Dallas County[16] showed a marked increase in January and February, as would be expected. Meteorological data for the 13 months of the study were examined and no correlation was found between carrier rates and precipitation, per cent of possible sunshine or relative humidity. The only possible association between the group A carrier rate and temperature occurred in July and August when the period with the lowest carrier rate corresponded to the months with the highest mean temperature.

The distribution of streptococcus carriers between the sexes was similar (Table 4). This is in contrast to the higher carrier rates found in males than in females by Frisch[17] and by Hartley and others.[18] Bourn, Carpenter, and McComb,[19] however, observed compar-

* A chi square test on the entire series of observations gives a probability of 0.3 that the observed differences might have occurred by chance.

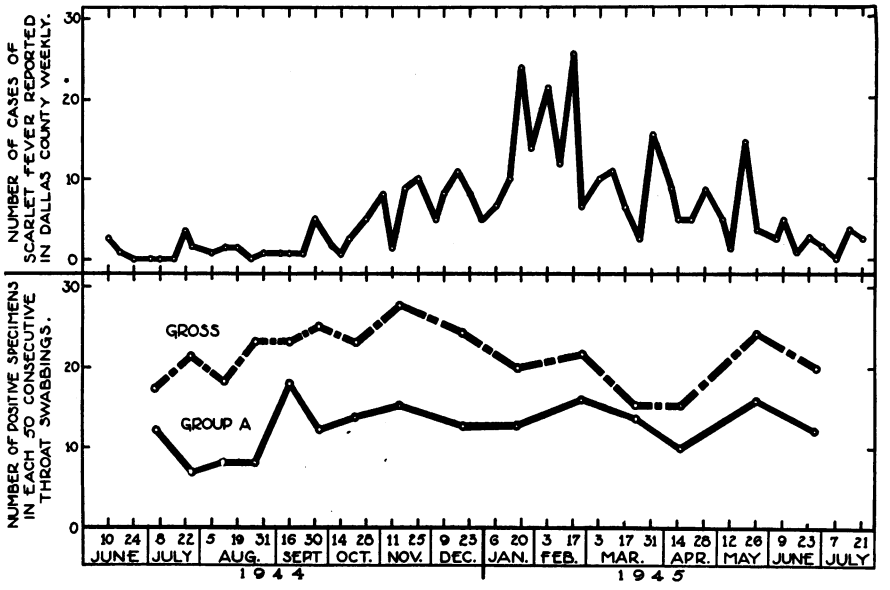


FIGURE 1—Seasonal Incidence of Streptococcus Carriers as Compared with the Seasonal Distribution of Scarlet Fever Reported in Dallas County

able rates in both sexes. The boys and girls in the present study were found to be comparable with respect to age and absence of tonsils, two factors which are shown below to affect the carrier rate. Tonsils had been removed in 24 per cent of the males and in 23 per cent of the females. In the three age groups, 0–4, 5–9, and 10–14, the males numbered 58, 234, and 168 and the females, 59, 240 and 141, respectively.

The importance of the presence of tonsils as a factor influencing the streptococcus carrier rate is shown by the high incidence of group A streptococci in excised tonsils [20–23] and by the higher carrier rates observed in individuals with tonsils than in those from whom

TABLE 3

*Hemolytic Streptococcus Carrier Rates for Each 50 Consecutive Throat Swabbings Cultured*

| | Carrier Rates | | |
|---|---|---|---|
| *Date* | *Gross* | *Group A* | *Groups B, C, D, F, G* |
| *1944* | *Per cent* | *Per cent* | *Per cent* |
| June 28–July 12 | 34 | 24 | 10 |
| July 13–Aug. 9 | 42 | 14 | 28 |
| Aug. 9–Aug. 17 | 36 | 16 | 20 |
| Aug. 18–Sept. 1 | 46 | 16 | 30 |
| Sept. 4–Sept. 26 | 46 | 36 | 10 |
| Sept. 26–Oct. 9 | 50 | 24 | 26 |
| Oct. 10–Oct. 31 | 46 | 28 | 18 |
| Nov. 1–Nov. 30 | 58 | 30 | 28 |
| Dec. 7–Dec. 29 | 48 | 26 | 22 |
| *1945* | | | |
| Jan. 4–Jan. 31 | 40 | 26 | 14 |
| Feb. 6–Mar. 16 | 44 | 34 | 10 |
| Mar. 20–Mar. 27 | 32 | 28 | 4 |
| Mar. 27–May 8 | 32 | 20 | 12 |
| May 8–June 14 | 48 | 34 | 14 |
| June 18–July 3 | 36 | 24 | 12 |

TABLE 4

*Carrier Rates According to Sex*

| Specimens | Male | | Female | | P |
|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | |
| Positive, all groups | 196 | 42.6 | 183 | 41.6 | >0.5 |
| Positive, group A | 125 | 27.1 | 99 | 22.5 | 0.11 |
| Positive, group C | 46 | 10.0 | 56 | 12.7 | 0.23 |
| Negative | 264 | 57.4 | 257 | 58.4 | .... |
| Total | 460 | | 440 | | |

tonsils had been removed.[17, 22, 24] The results of cultures in children with and without tonsils are shown in Table 5 and Figure 2. Tonsils had been removed from 24 per cent of the subjects. Gross and group A carriers were about twice as frequent in the group with tonsils as in those without. Since the proportion of tonsillectomies increased with age and since carrrier rates were also affected by age, an adjustment of these rates for age seemed indicated. The difference between age adjusted carrier rates in children with and without tonsils was even greater than the difference in crude rates because the 0–4 year group which had the highest proportion of tonsils showed the lowest carrier rates. It was surprising to find that removal of tonsils also lowered the carrier rate for group C organisms, a finding which would not be expected from the relatively low incidence of groups other than A reported in excised tonsils.[21-23]

Carrier rates for the three racial groups are shown in Table 6 and Figure 3. Since tonsils were absent in 29 per cent of white, 17 per cent of the colored, and 33 per cent of the Mexican children, the rates were adjusted for this factor. There was no significant difference in the incidence of group A carriers in the three racial groups. The differences in the frequency of group C

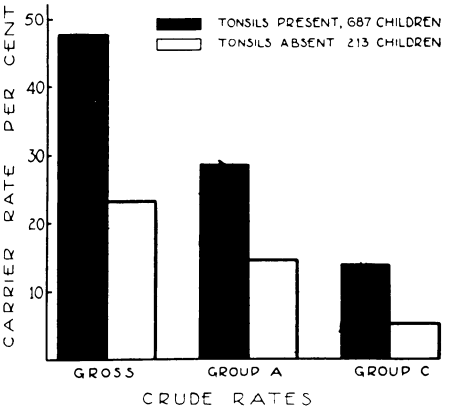


FIGURE 2—Streptococcus Carrier Rates in Children with and without Tonsils

TABLE 5

*Crude and Age Adjusted Carrier Rates in Children With and Without Tonsils*

| Specimens | Tonsils: Present | | | Tonsils: Absent | | | P |
|---|---|---|---|---|---|---|---|
| | Number | Crude Rate Per cent | Age Adjusted Rate Per cent | Number | Crude Rate Per cent | Age Adjusted Rate Per cent | (Crude and Adjusted) |
| Positive, all groups | 329 | 47.9 | 48.5 | 50 | 23.5 | 20.9 | <0.0001 |
| Positive, group A | 194 | 28.2 | 28.5 | 30 | 14.1 | 12.1 | <0.0001 |
| Positive, group C | 91 | 13.2 | 13.5 | 11 | 5.2 | 4.6 | <0.0001 |
| Negative | 358 | 52.1 | 51.5 | 163 | 76.5 | 79.1 | ..... |
| Total | 687 | | | 213 | | | |

TABLE 6

*Crude Carrier Rates and Carrier Rates Adjusted for Presence or Absence of Tonsils in Different Races*

| | White | | | Colored | | | Mexican | | | P | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Specimens* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Crude* | *Adjusted* |
| Positive, all groups | 167 | 39.2 | 40.3 | 170 | 43.0 | 40.8 | 42 | 53.2 | 54.7 | 0.2 | 0.2 |
| Positive, group A | 110 | 25.8 | 26.6 | 97 | 24.6 | 23.6 | 17 | 21.5 | 22.5 | 0.8 | 0.7 |
| Positive, group C | 29 | 6.8 | 7.0 | 56 | 14.2 | 13.0 | 17 | 21.5 | 21.7 | <0.01 | <0.01 |
| Negative | 259 | 60.8 | 59.7 | 225 | 57.0 | 59.2 | 37 | 46.8 | 45.3 | .... | .... |
| Total | 426 | | | 395 | | | 79 | | | | |

streptococci, however, are not likely to have resulted from chance. These differences are reflected in the gross carrier rates. No explanation is apparent. The three racial groups belonged to families of similar economic status since all qualified for clinic care. The colored and Mexican children represented more or less distinct social groups, each residing in a separate section of the city and attending its own schools.

One of the most important factors affecting the carrier rates is age (Table 7, Figure 4). As has been shown by Schwentker and others,[1] gross and group A rates in preschool children were lower than in the 5–9 and 10–14 year groups.

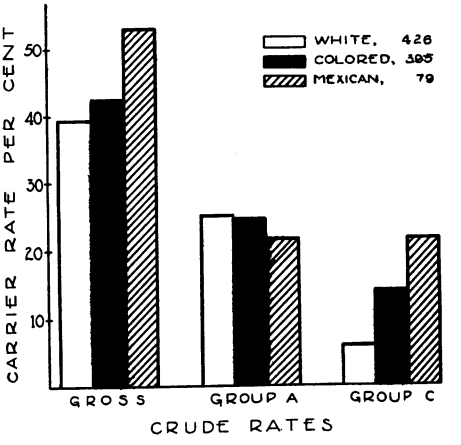


FIGURE 3—Streptococcus Carrier Rates in Different Races

TABLE 7

*Crude Carrier Rates and Carrier Rates Adjusted for Presence or Absence of Tonsils in Different Age Groups*

| | 0–4 Years | | | 5–9 Years | | | 10–14 Years | | | P | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Specimens* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Number* | *Crude Rate Per cent* | *Rate Adjusted for Tonsils Per cent* | *Crude* | *Adjusted* |
| Positive, all groups | 35 | 29.9 | 23.8 | 214 | 45.1 | 45.9 | 130 | 42.1 | 37.8 | 0.1 | <0.01 |
| Positive, group A | 24 | 20.5 | 16.3 | 132 | 30.0 | 35.0 | 67 | 21.7 | 22.2 | 0.2 | <0.01 |
| Positive, group C | 8 | 6.8 | 5.4 | 51 | 10.8 | 11.7 | 43 | 13.9 | 14.1 | 0.1 | 0.05 |
| Negative | 82 | 70.1 | 76.2 | 260 | 54.9 | 54.1 | 179 | 57.9 | 62.2 | ... | .... |
| Total | 117 | | | 474 | | | 309 | | | | |

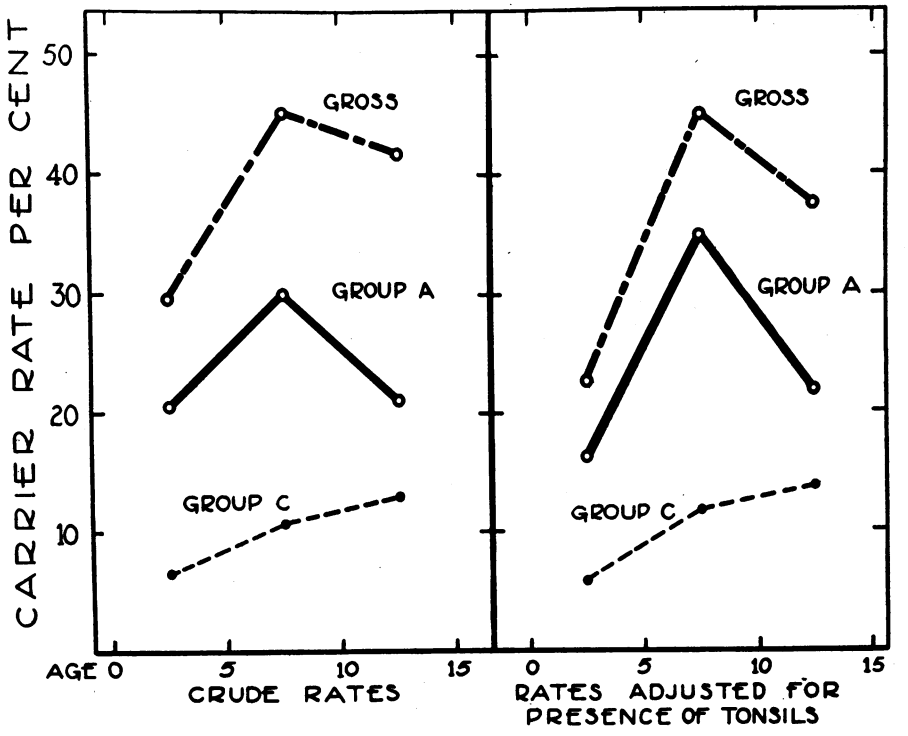


FIGURE 4—Streptococcus Carrier Rates in Different Age Groups

The age group with the highest rates, 5–9 years, corresponds to the group in which streptococcus upper respiratory infections are most often seen and in which first attacks of rheumatic fever are most likely to occur. In contrast to the group A carrier rate, that for group C continued to increase with age. The variation of carrier rates with age is even more apparent when the presence or absence of tonsils is taken into account. Tonsils had been removed from 4, 26, and 27 per cent of the respective age groups.

## DISCUSSION

Reviewing the hemolytic streptococcus carrier studies which had been done prior to 1939, Hare [25] concluded that the normal group A carrier rate was about 7 per cent. Since that time several studies based on large numbers of examinations have recorded rates two or three times this figure. In Table 8 we have summarized carrier studies performed in various parts of the world in which serological grouping, at least to the extent of separating the members of group A, was done. A number of reports on closed populations and military groups have been omitted because they did not appear to represent normal situations. The conditions under which the summarized results were carried out included too many variables to permit an analysis with respect to factors which may affect the carrier rate. It is of interest to note, however that the highest group A carrier rate was obtained in Dallas which is nearer the equator than any other locality recorded with the exception of Hong Kong. The latter showed the lowest rate of all. The high gross and group A rates found in Dallas are due to a large extent to the method of making cultures. This is the only study in which enrichment broth was used. Gross and group A rates based

TABLE 8

*Summary of Hemolytic Streptococcus Carrier Studies in Which Serological Grouping Was Reported*

| *Locality* | *Latitude* | *Season* | *Subjects* | *Swabbings Examined* | *Carrier Rate Per cent* | | *Strains Not Group A* | | | | | | | | *Authors* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Gross* | *Group A* | *B* | *C* | *D* | *E* | *F* | *G* | *H* | *K* | |
| London | +51 | | Nurses, school boys, normal adults | 750 | 20 | 8 | 5 | 15 | 0 | 0 | 12 | 13 | 25 | 8 | Hare [26] |
| Hong Kong | +22 | Winter | Chinese of all ages | 788 | 10 | 4 | 0 | 23 | 0 | 0 | 0 | 27 | .. | .. | Davis and Guzdar [27] |
| Edinburgh | +56 | | Nonrheumatic hospital patients | 200 | 30 | 13 | 9 | 16 | 1 | 0 | 0 | 6 | 2 | 0 | Green [9] |
| Madison | +43 | Autumn | University students | 621 | 16 | 6 | .. | .. | .. | .. | .. | .. | .. | .. | Frisch [17] |
| Tokyo | +35 | Autumn | School children, 7–14 years | 410 | 26 | 10 | 1 | 30 | 0 | 0 | 7 | 28 | .. | .. | Kodama and others [28] |
| Melbourne | −37 | Spring and Autumn | Hospital personnel | 115 | 22 | 9 | .. | .. | .. | .. | .. | .. | .. | .. | Bryce and Tewsley [29] |
| Tokyo | +35 | Winter | School children, 7–9 years | 621 | 23 | 11 | .. | .. | .. | .. | .. | .. | .. | .. | Kodama and others [30] |
| Melbourne | −37 | | Mainly adults | 218 | 25 | 6 | .. | .. | .. | .. | .. | .. | .. | .. | Keogh and Kelsey [31] |
| Melbourne | −37 | Summer and Autumn | Adults and Children | 466 | 18 | 5 | .. | .. | .. | .. | .. | .. | .. | .. | Keogh and others [21] |
| Melbourne | −37 | | School children 4 to 14 years | 210 | 27 | 13 | .. | .. | .. | .. | .. | .. | .. | .. | Macdonald and others [22] |
| San Francisco | +38 | Entire year | Preoperative tonsillectomy patients, 70% children | 298 | 26 | 16 | 5 | 12 | 0 | 0 | 4 | 6 | 0 | .. | Rantz [23] |
| Iowa | +42 | | Children admitted to orthopedic hospital | 1,201 | 17 | 8 | 70 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | Jones and others [32] |
| Roumania | +45 | Entire year | 0–14 years | 11,625 | 35 | 19 | .. | .. | .. | .. | .. | .. | .. | .. | |
| | | | 15 years | 7,802 | 23 | 14 | .. | .. | .. | .. | .. | .. | .. | .. | Schwentker and others [1] |
| England | +51 | | Patients and nursees in surgical ward | 1,553 | 43 | 19 | 0 | 11 | .. | .. | .. | 3 | .. | .. | Williams and Harper [33] |
| Dallas | +32 | Entire year | Well children, 0–15 years | 900 | 42 | 25 | 8 | 102 | 12 | 0 | 23 | 27 | 0 | .. | This report |

on the 429 throat specimens which were cultured directly on blood agar plates were 14 and 8 per cent respectively. These figures are below the averages of the rates obtained in other studies.

In view of the frequency of group A streptococci in normal throats, the question of the significance of the carrier naturally arises. Hare [25, 34] considered carriers of prime importance as sources of wound infection. Whether or not all carriers are potential sources of such infections is not apparent. Boisvert, Darrow, Powers, and Trask [35] state that the presence of hemolytic streptococci in the nose or throat of a child is usually significant. On the other hand, the diagnostic significance of a positive throat culture is seriously questioned by the report of Dingle and others [36] who found that only half the patients with exudative pharyngitis and positive throat cultures showed a significant rise in antistreptolysin. Assuming that hemolytic streptococcus infections are usually followed by a rise in antistreptolysin,[37] the implication is that nearly half the positive cultures were incidental. The significance of carriers is minimized by Coburn and Pauli [38] who believe that carriers usually do not communicate disease and usually may be considered harmless. Although the serological technic by which the Lancefield groups of streptococci are recognized is valuable in eliminating many strains belonging to groups not frequently associated with disease in man, it is evident that many more group A strains could be designated as harmless, at least from an epidemiological standpoint, if one could determine the factor which has been termed communicability [38, 39] or dispersability.[11]

Our failure to detect any significant variation in the group A carrier rate from September to June was contrary to expectation. Coburn and Pauli [38, 40] stated that the gross hemolytic streptococcus carrier rate in New York City increased during the winter, reaching a peak in early spring. A similar trend in the group A carrier rate was observed by Rantz in San Francisco.[23] Schwentker, Janney, and Gordon [1] found a definite seasonal trend over a three year period in both gross and group A rates in Roumania with the highest rates occurring in the autumn months. Hodes and others [11] noted a marked seasonal variation in the group A carrier rate among naval recruits. Other studies have failed to reveal a relationship between carrier rates and season. Bourn and others [19] found no seasonal trend in Baltimore. Observations over a period of several years in London by Straker, Hill, and Lovell [41] revealed considerable variability in rates from year to year but no consistent seasonal distribution. They did, however, observe some tendency for the carrier rate to increase as the amount of sunshine increased and the relative humidity decreased. Neither of the last two studies separated the group A streptococci. These and our own results suggest that if seasonal factors affect the carrier rate, the association may be obscured by other influences.

Several investigators have demonstrated an association between the group A streptococcus carrier rate and the incidence of streptococcal disease. Schwentker, Janney, and Gordon [1] and Schwentker [6, 7] have shown very definite increases in carrier rates, particularly of the epidemic type, during outbreaks of scarlet fever. The same authors [1] also found that the seasonal variations in the normal carrier rate in communities free from scarlet fever were closely parallel with the incidence of scarlet fever in neighboring counties. Van Ravenswaay [8] found a tendency for streptococcal disease to occur with greater frequency at Army Air Forces installations with high carrier rates than in those with low rates. It is evident, however, that an increase in the incidence of carriers is not necessarily followed

by an increase in disease, even in closed populations, since Hartley and others [18] observed a rate of 88 per cent among boys in a home for crippled children without any cases of infection.

In Dallas County (Figure 1) the reported incidence of scarlet fever showed a gradual increase during the autumn, reached a peak in January and February, and declined during the spring. Neither the gross nor group A streptococcus carrier rates showed such a pattern. The only similarity between the seasonal incidence of scarlet fever and the frequency of carriers lies in the fact that low points were observed for both during July and August. It would appear that the sample of the Dallas County population which we examined should have been sufficient to reveal an association between scarlet fever and carrier rate had there actually been one. In spite of the close relationship between carrier rate and incidence of disease observed in some instances, our results together with those of others indicate that an increase in streptococcal disease is not necessarily accompanied by an increase in normal carriers and that a high carrier rate does not necessarily mean a high incidence of disease.

The effect of tonsil removal on the group A streptococcus carrier rate as shown by our results, although significant, is less marked than that observed by others. MacDonald, Simmons, and Keogh [22] found group A streptococci six times as frequently in children with tonsils as in those without. In college students examined by Frisch [17] there was a threefold difference. Wheeler and Jones [24] found that tonsils were associated with the carrier state and also with streptococcal disease in naval personnel, although they imply that a similar correlation has not been observed in childhood age groups. In the first two of these studies tonsillectomy produced very little effect on the carrier rates for groups other than A. The fact that our group C carrier rate was also significantly lowered by tonsillectomy suggests that the tonsils serve as reservoirs of these organisms as well as for the group A streptococci. Kuttner and Krumwiede,[10] on the other hand, found that the length of the carrier state was not related to the presence or absence of tonsils. The finding of lower carrier rates in tonsillectomized individuals is not in itself an argument for indiscriminate tonsillectomy. Any reduction in the number of carriers is presumably desirable,[22] but evidence that the carrier state is detrimental to the individual is lacking. Wendkos,[42] for example, concluded that tonsillectomy in childhood was not a deterrent to subsequent rheumatic fever.

In two respects the group C streptococcus carrier rates differed from the group A. First, there were racial differences in the incidence of group C organisms. Some factor, not apparent, which was responsible for these differences failed to influence the group A rates. Second, the distribution of the two groups of streptococci with respect to age was not the same. It would be necessary to make observations on several older age groups to complete the picture, but whatever causes the decrease in the group A carrier rate beyond the age of 10 is either delayed or noneffective in reducing the dissemination of the group C streptococci.

Our failure to isolate significantly more hemolytic streptococci on plates incubated anaerobically as compared with those incubated aerobically is contrary to the experience of Jones, Holmes, and Hale.[32] We did notice a marked inhibition of the large colony forms of Gram-positive and Gram-negative cocci on the anaerobic plates which may in part account for any advantage that may be found for anaerobic plates. Also, the increased hemolytic activity which many group A streptococci show under anaerobic conditions [43, 44] might be ex-

pected to lead to their more frequent recognition under these conditions.


## SUMMARY

Throat specimens from 756 children over a period of 13 months were examined for beta hemolytic streptococci by the use of sodium azide-crystal violet enrichment broth. Serologically identified streptococci were isolated from 42 per cent of the 900 specimens; group A streptococci from 25 per cent. Direct platings of the 429 throat swabs showed hemolytic streptococci of all groups in 14 per cent and group A in 8 per cent. Anaerobic incubation of direct platings from 155 specimens did not significantly increase the number of positive cultures. The use of streaked-poured plates containing sodium azide and crystal violet in culturing 81 throat swabs showed no advantage over surface-streaked plates without the inhibitors.

Repeated swabbings markedly increased the proportions of individuals found to be carriers of beta hemolytic streptococci. The gross and group A carrier rates for each fifty consecutive swabbings varied between 32 and 58 per cent and 14 and 36 per cent respectively. No association between carrier rates and season or between carrier rates and incidence of scarlet fever was found except that the lowest group A rates occurred during the warmest months when scarlet fever incidence was low.

Gross and group A carrier rates were similar for both sexes and for white, colored, and Mexican children. A significant racial difference was found, however, in the incidence of group C streptococci. More than twice as many carriers of group A and group C organisms were found among children with tonsils as among those without tonsils. Gross and group A carrier rates increased with age up to 10 years and then declined, but the group C rate continued to increase.

The results are discussed in relation to hemolytic streptococcus carrier studies in other parts of the world.


## REFERENCES


1. Schwentker, F. F., Janney, J. H., and Gordon, J. E. The Epidemiology of Scarlet Fever. *Am. J. Hyg.*, 38:27, 1943.
2. Anon. Notifiable Diseases, Year 1944. *Pub. Health Rep.*, 60:334, 1945.
3. Stebbins, E. L. Scarlet Fever and Related Streptococcal Infections. *Med. Clin. N. A.*, 27:661, 1943.
4. *Vital Statistics of the United States*, 1942, part 2, p. 16.
5. Fashena, G. J. The Incidence of Rheumatic Fever in Texas with Particular Reference to the Dallas Area. *Texas State J. Med.*, 39:474, 1944.
6. Schwentker, F. F. Relation between Scarlet Fever Morbidity and Streptococcus Carrier Rates. *Am. J. Hyg.*, 38:207, 1943.
7. Schwentker, F. F. Survey of Hemolytic Streptococci in Certain Army Camps. *Army Med. Bul.*, 65:94, 1943.
8. Van Ravenswaay, A. C. The Geographic Distribution of Hemolytic Streptococci. Relationship to the Incidence of Rheumatic Fever. *J.A.M.A.*, 126: 486, 1944.
9. Green, C. A. Serological Examination of Hemolytic Streptococci from Acute Rheumatic and Control Groups. *Brit. M. J.*, 1:1147, 1938.
10. Kuttner, A. G., and Krumwiede, E. Observations on the Epidemiology of Streptococcal Pharyngitis and the Relation of Streptococcal Carriers to the Occurrence of Outbreaks. *J. Clin. Investigation*, 23:139, 1944.
11. Hodes, H. L., Schwentker, F. F., Chenworth, B. M., and Peck, J. L. Scarlet Fever as an Airborne Infection. *Am. J. M. Sc.*, 209:64, 1945.
12. Pike, R. M. An Enrichment Broth for Isolating Hemolytic Streptococci from Throat Swabs. *Proc. Soc. Exper. Biol. & Med.*, 57:186, 1944.
13. Pike, R. M. The Isolation of Hemolytic Streptococci from Throat Swabs. Experiments with Sodium Azide and Crystal Violet in Enrichment Broth. *Am. J. Hyg.*, 41:211, 1945.
14. Pike, R. M. The Isolation of Hemolytic Streptococci from Throat Swabs. II. The Efficiency of Human and Rabbit Blood in Streaked and Streaked-poured Plates. *J. Lab. & Clin. Med.*, 30:518, 1945.
15. Pike, R. M. The Isolation of Hemolytic Streptococci from Throat Swabs. III. Value of Enrichment Broth Containing Potassium Tellurite and Crystal Violet. *J. Bact.*, 50:297, 1945.
16. *Texas Morbidity This Week*, Texas State Dept. of Health, 1944–1945.
17. Frisch, A. W. Hemolytic Streptococci from the Throat of Normal Young Adults. *J. Infect. Dis.*, 62:40, 1938.
18. Hartley, G., Jr., Enders, J. F., Mueller, J. H., and Schoenback, E. B. Absence of Clinical Disease in Spite of a High Incidence of Carriers of Group A Hemolytic Streptococci of a Single Type; Failure of Tyrothricin to Influence the Carrier Rate. *J. Clin. Investigation*, 24:92, 1945.
19. Bourn, J. M., Carpenter, H. M., and McComb, E. Streptococcus Haemolyticus (beta) in the Presence and Absence of Acute Minor Respiratory Infection, 1928–1931, *Am. J. Hyg.*, 17:761, 1933.
20. Elliott, S. D. Bacteriaemia Following Tonsillectomy. *Lancet*, 237:589, 1939.
21. Keogh, E. V., MacDonald, I, Battle, G., Simmons, R. T., and Williams, S. The Serological Groups and Types of Streptococci Isolated from Excised Tonsils. *Brit. M. J.*, 2:1036, 1939.
22. MacDonald, I., Simmons, R. T., and Keogh,

E. V. Further Observations on the Incidence of Haemolytic Streptococci in the Tonsils. *Med. J. Australia,* 1:849, 1940.

23. Rantz, L. A. The Hemolytic Streptococci. Studies on the Carrier State in the San Francisco Area with a Note on the Methods of Isolation and Serological Classification of these Organisms. *J. Infect. Dis.,* 69:248, 1941.

24. Wheeler, S. M., and Jones, T. D. Factors in the Control of the Spread of Acute Respiratory Infections with Reference to Streptococcal Illness and Acute Rheumatic Fever. *Am. J. M. Sc.,* 209:58, 1945.

25. Hare, R. Sources of Haemolytic Streptococci. *Lancet,* 1:109, 1940.

26. Hare, R. The Classification of Haemolytic Streptococci from the Nose and Throat of Normal Human Beings By Means of Precipitin and Biochemical Tests. *J. Path. & Bact.,* 41:499, 1935.

27. Davis, L. J., and Guzdar, J. S. The Serological, Toxigenic and Biochemical Reactions of Haemolytic Streptococci from the Throats of Hong Kong Chinese. *J. Path. & Bact.,* 43:197, 1936.

28. Kodama, T., Ozaki, M., Nishiyama, S., and Chiku, Y. The Serological Grouping and Typing of the Hemolytic Streptococci Isolated in Tokyo. II. *Kitasato Arch. Exper. Med.,* 15:162, 1938.

29. Bryce, L. M., Tewsley, P. Bacteriological and Clinical Study of Professional Personnel of Maternity Hospitals with Special Reference to Carriers of Haemolytic Streptococci. *Med. J. Australia,* 1:639, 1938.

30. Kodama, T., Ozaki, M., Nishiyama, S., Igarasi, J., Tiku, Y., and Kawamura, H. The Serological Grouping and Typing of Hemolytic Streptococci Isolated in Tokyo. III. *Kitasato Arch. Exper. Med.,* 16:110, 1939.

31. Keogh, E. V., and Kelsey, H. Observations on the Epidemiology of Streptococcal Infections. *Med. J. Australia,* 1:100, 1939.

32. Jones, M., Holmes, L. F., and Hale, W. M. Relative Efficiency of Aerobic and Anaerobic Methods in the Isolation of Beta-hemolytic Streptococci. *J. Bact.,* 42:138, 1941.

33. Williams, R. E. O., and Harper, G. J. The Frequency of Haemolytic Streptococci of Different Groups in the Normal Nose and Throat. *Month. Bull.* Emerg. Pub. Health Lab., 3:86, 1944.

34. Hare, R. Haemolytic Streptococci in Normal People and Carriers. *Lancet.,* 240:85, 1941.

35. Boisvert, P. L., Darrow, D. C., Powers, G. F., and Trask, J. D. Streptococcosis in Children. A Nosographic and Statistical Study. *Am. J. Dis. Child.,* 64:516, 1942.

36. Dingle, J. H., Abernathy, T. J., Badger, G. F., Beard, J. W., Cressy, M. L., Feller, A. E, Langmuir, A D., Rammelkamp, C. H., and Strauss, E. Endemic Exudative Pharyngitis and Tonsillitis. Etiology and Clinical Characteristics. *J.A.M.A.,* 125:1163, 1944.

37. Mote, J. R., and Jones, T. D. Studies of Hemolytic Streptococcal Antibodies in Control Groups, Rheumatic Fever, and Rheumatoid Arthritis. II. The Frequency of Antistreptolysin "O", Antifibrinolysin, and Precipitating Antibody Responses in Scarlet Fever, Hemolytic Streptococcal Infections, and Rheumatic Fever. *J. Immunol.,* 41:61, 1941.

38. Coburn, A. F., and Pauli, R. H. The Interaction of Host and Bacterium in the Development of Communicability by *Streptococcus Haemolyticus. J. Exper. Med.,* 73:551, 1941.

39. Coburn, A. F. The Carrier Problem in the Dissemination of Hemolytic Streptococcus. *U. S. Nav. M. Bull.,* 42:325, 1944.

40. Coburn, A. F., and Pauli, R. H. Studies on the Relationship of Streptococcus Hemolyticus to the Rheumatic Process. I. Observations on the Ecology of Hemolytic Streptococcus in Relation to the Epidemiology of Rheumatic Fever. *J. Exper. Med.,* 56:609, 1932.

41. Straker, E., Hill, A. B., and Lovell, R. A Study of Nasopharyngeal Batcerial Flora of Different groups of persons Observed in London and South-east England During the Years 1930–1937. *Reports on Public Health and Medical Subjects,* No. 90.

42. Wendkos, M., Rheumatic Fever in the Army from the Pediatricians Point of View. *Am. J. Dis., Child.,* 68:222, 1944.

43. Fry, R. M. Anaerobic Methods for the Identification of Haemolytic Streptococci. *J. Path. & Bact.,* 37:337, 1933.

44. Fuller, A. T., and Maxted, W. R. The Production of Haemolysin and Peroxide by Haemolytic Streptococci in Relation to the Non-Haemolytic Variants of Group A. *J. Path. & Bact.,* 49:83, 1939.