Epidemiologic observations on trachoma in the United States

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Trachoma, by virtue of its poor immunizing properties and chronicity, bears a certain epidemiologic resemblance to tuberculosis and leprosy and is in consequence difficult to eradicate.

In the United States, as in most areas of the world, trachoma is a disease of the family. Infection often takes place in early life as a result of close contact between mother or grandmother and child, or between preschool siblings. No true carrier state has been demonstrated in trachoma but the frequency of minimal disease subject to periodic exacerbation is believed to be an important factor in its epidemiology.

In addition to close contact in the family, other factors with a bearing on the epidemiology of trachoma include poverty, poor personal hygiene related to deficient water supply, low educational standards, inadequate housing, and tropical or subtropical conditions conducive to fly proliferation and seasonal epidemics of bacterial conjunctivitis. Sporadic cases of trachoma in adults still occur in the United States and are probably related to existing foci of trachoma in the communities concerned.

An understanding of the epidemiology of trachoma is essential if its eradication is to be accomplished.

Trachoma has been a disease of the white population of the United States since colonial times. It was particularly prevalent among the mountain people of Scotch-Irish descent in the Virginias who migrated west across the Appalachians along the so-called "Daniel Boone Trail" to what is now Kentucky, southern Indiana and southern Illinois, Missouri, Oklahoma, and Arkansas. According to Gradle,\textsuperscript{1} about 75 per cent of all cases of trachoma in the white population in the 1920's were in this trachoma belt where the living conditions and standards of personal hygiene among the impoverished mountain folk were primitive and poor. The extent of the trachoma problem in this area is indicated by the results of a 1912 survey of 35 counties of eastern Kentucky; as reported by Sory,\textsuperscript{2} 33,000 cases were found in this small area.

In Kentucky, the U. S. Public Health Service opened its first special trachoma hospital in September, 1913. From that time it operated from one to four such hospitals until 1926, when the combined work was taken over by a central hospital located at Richmond. During this period the U. S. Public Health Service also opened and operated trachoma hospitals in Missouri, Oklahoma, and Arkansas. Meanwhile, in Illinois and Arkansas, the state public health authorities operated a series of trachoma clinics. The need for all these efforts was underscored by the fact that trachoma remains a serious problem in these areas today.

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services gradually diminished, and one by one both clinics and hospitals closed down. The last trachoma hospital to function was the one at Rolla, Missouri, which closed its doors early in the 1950's. The extent of the visual damage caused by trachoma in these trachoma states is indicated by figures showing that at the beginning of the trachoma control campaign the disease was responsible for 9.6 per cent of the blindness in Indiana, 13.1 per cent in Arkansas, 13.7 per cent in Kentucky, and 23.3 per cent in Oklahoma.

Trachoma in the white population of other areas of the United States never reached major proportions. It has occurred sporadically almost everywhere, however, and by 1930 had become a reportable disease in 44 states. It is unlikely that reporting has ever been complete. In the decade from 1935 to 1945 there were no reported cases in five states, yet it seems safe to assume that there were at least a few cases in that period in every state in the Union. All observers have noted the close relationship of the disease to poverty and poor personal hygiene.

Trachoma has been a common disease of the American Indian for at least a hundred years,6 and very likely since before the white man's arrival on the American continent. The best guess would seem to be that the Indian brought it with him from "Mongolia" in the course of his presumed first migrations from Asia. The only other possibility would seem to be that the Spaniard brought it to him in the sixteenth and seventeenth centuries. In any event, the "sore eyes" found by Lewis and Clark among the Shoshone, in what is now Idaho, was in all probability trachoma. The first mention of the disease by name was made by W. J. McCormick in 1868 in a report to the U. S. Indian Service from his post at the Flathead Indian Agency of Montana Territory. From that time other Indian Service physicians began to include trachoma in their medical reports, and in 1912 a survey of western tribes indicated that 22.7 per cent of 39,031 Indians examined had trachoma. Only a few tribes appear to have escaped, notably the Seminoles of Florida and the various Alaskan tribes. Surveys have indicated that about 1 per cent of trachoma in Indians has produced total blindness; accurate figures on visual impairment, which has been extensive, are not available, however.

Trachoma never has been an important disease of the American Negro even though poverty and poor personal hygiene have been common features of Negro life. It is found among oriental immigrants on the West Coast, in spite of strenuous efforts on the part of immigration officials to exclude it, and there are important foci in the Mexican population of our western states. There is no doubt that the disease is still being brought into the country from foci known to exist in a number of Mexican states, for example, Sonora.

Although trachoma is still endemic in the white and Mexican populations, and still a major disease problem of the Indians of the southwest, in recent years it has diminished strikingly in the white population and among the northern Indian tribes. This diminution of the disease in the United States is due in part to the efficacy of the trachoma control programs, but even more, there is good reason to believe, to improvement in standards of living and health education. The purpose of this paper is to discuss the characteristics of trachoma and its etiological agent which led first to its widespread distribution in the United States, and recently to its reduced prevalence in the white population and northern Indian tribes.

Characteristics of trachoma having a bearing on epidemiology

Trachoma can be defined as a widespread chronic keratoconjunctivitis characterized by conjunctival cicatrization and reduced vision resulting from corneal scars and pannus. It is seen most commonly in preschool children and is a very serious problem in tropical and subtropical areas where the population's socioeconomic level
is low and seasonal bacterial conjunctivitis prevalent. Its epidemiology bears a certain resemblance to that of tuberculosis and leprosy, particularly with respect to the importance of prolonged family contact.

The florid and cicatricial stages of trachoma are easy to recognize, but the relatively asymptomatic form that characterizes childhood trachoma is often missed or is confused with folliculosis or chronic follicular conjunctivitis. It is this childhood form that is important in the spread of the disease in both family and community. Trachoma acquired in adulthood usually has an acute onset and is diagnosed and treated promptly enough to prevent it from spreading.

The difficulty of determining a cure in trachoma, especially in old cicatricial cases, has a bearing on epidemiology. Reactivation of apparently healed disease in immigrants has been observed repeatedly. In our Indian population of the southwest and among the White Mountain Apaches in particular, I have seen families in which the parents were either free from trachoma or had inactive disease but in which the preschool children or young school children had fresh disease, derived apparently from the activation of an old trachoma in one of the grandparents. We have seen this happen with tuberculosis; phlyctenulosis in young children has been traced to the activation or development of tuberculosis in a grandparent.

Clinical examination is not entirely satisfactory as a means of determining the state of healing, and laboratory procedures are not yet sufficiently refined. A positive cortisone-reactivation test can be useful but unfortunately the value of a negative test has not yet been established. It is possible that the immunofluorescence technique applied to conjunctival scrapings will prove to be valuable.

Characteristics of the trachoma agent having a bearing on epidemiology

It is known that the elementary body of trachoma is susceptible to desiccation, that it soon becomes inactivated at room temperature even in the wet state, and that in the chronic form of the disease its numbers in the scanty exudate are small. These features probably account for the low communicability of the disease and the consequent necessity for intimate household contact to produce infection. Another characteristic of the trachoma agent, common to all members of the psittacosis-lymphogranuloma-trachoma (PLT) group, is its failure to induce immunity—a feature that probably accounts for the long duration of the disease and for the reinfections that are so common among school children who have been treated successfully during the school year.

The epidemiology of trachoma is influenced by the prolonged treatment time necessary to effect a cure. This may account for the failure to modify the disease in the adult population of some of our heavily infected western Indian tribes whose migratory habits and reluctance to seek or accept medical care make treatment difficult. If it were possible to cure all patients within a week, as is the case with inclusion conjunctivitis, treatment programs for adult populations would be relatively successful.

The epidemiology is also affected by the characteristic association of trachoma virus with conjunctivitis-producing bacteria, particularly *H. aegyptius* and *M. lacunata*. Such secondary bacterial infection is a feature of trachoma in our southwest. A symbiotic relationship has been suggested since bacterial infection often has the effect of increasing the activity of the underlying PLT agent. In Egypt the fulminating keratoconjunctivitis known as "Egyptian ophthalmia" is a combined infection of trachoma virus with *H. aegyptius* or *N. gonorrhoeae*, or both.

Environmental factors of epidemiologic significance

The household unit. Since trachoma is known to spread chiefly in the home, the characteristics of the home environment
are important. In general, trachomatous homes are poverty-stricken homes. This is true even in communities in which the general standard of living is low. One can almost always pick out on sight the homes where trachoma will be found to be rampant. In a 1963 study of Blackwater, a Pima community where 75 per cent of the day school children were found to have trachoma, Foster noted a definite familial aggregation of cases.

In a consideration of the home environment on the Apache reservation, I failed to find a clear-cut sex difference; but in many parts of the world trachoma is much more common among girls than boys, possibly because of the girls' more intimate contact with their mothers, and, in some Arab countries, because girls are denied medical care as a result of religious taboos.

Other factors in the home environment with a bearing on epidemiology include: (1) availability of water for washing, (2) cultural and religious traditions of the family, (3) educational status of the parents, (4) dust, and (5) flies. Running water in the home usually reflects a relatively good economic situation and health consciousness on the part of the parents. In Indian villages, availability of water has usually been associated with a low trachoma index, although there is often a lag of several years between the introduction of running water into an Indian community and a drop in the index of active disease. When cultural and religious traditions favor personal cleanliness, trachoma tends to be rare, but the educational level of the parents plays an even more important role. The health consciousness that develops with education is almost inevitably associated with a low trachoma index. Among other factors, educated parents recognize illness in their children earlier than uneducated parents so that medical aid for eye diseases is sought more promptly.

Dust in the home and dust storms in the environment cause eye irritations mechanically. The eyes are then rubbed and various types of conjunctivitis, particularly the bacterial types (e.g., Koch-Weeks conjunctivitis), which may act as carriers for trachoma virus, are transmitted to the eyes by contaminated fingers. The fly has been incriminated by most trachomatologists as a mechanical transmitter of epidemic bacterial conjunctivitis, and by some as a transmitter of trachoma virus. However, although a number of attempts have been made to cultivate virus from flies that have been in contact with the trachomatous conjunctiva, only failure has been reported.

A gnat-born Koch-Weeks seasonal conjunctivitis is common in several of our southern states, particularly in the Rio Grande valley of Texas and in the Coachella valley of California where it is associated with trachoma. My associate, Chandler Dawson, has reported an extensive study of epidemic Koch-Weeks conjunctivitis in the Coachella valley and its relation to gnat-breeding seasons.

**Occupation.** In several Mediterranean countries a relatively high incidence of trachoma has been noted in fishing villages. This has not been the case in the United States, however. The only clear-cut occupational relationship that I have observed personally in the United States is to wrestling. I have myself treated 6 professional wrestlers for trachoma. The habit of using the fingers to massage an opponent's eyeballs to invoke the vagus reflex has been said to promote transmission. If the disease is related to any other occupation at present it may be to farming. Most of the Mexican, Indian, and oriental children we have seen with the disease have come from agricultural families.

**The school.** Although a few new cases of trachoma have occasionally developed during the school year in children in Indian boarding schools (e.g., in the Stewart Indian School near Carson City, Nevada), transmission in schools is not common. At Stewart and at other schools I have surveyed regularly, both trachoma and bacterial conjunctivitis are detected and treated
early so that spread is minimized. In addition, personal hygiene is taught and in general is enforced. In school surveys it is rare to find a trachomatous child whose parents or siblings are free from trachoma; whenever such a child is found, school transmission is presumed.

There can be no doubt, however, that occasional cases of trachoma develop in school children, not only in Indian but in Mexican and white school children as well. I have seen a number of children in well-to-do white families who have developed trachoma while in schools where trachoma was known to exist; in the families and among the home contacts of these children no cases of the disease could be found. One such child, a 12-year-old girl, developed a unilateral trachoma. Her disease remained unilateral for 2 years when sulfonamide treatment finally was instituted. Undiagnosed, it had been treated as a benign follicular conjunctivitis while ptosis, cicatrization, and gross pannus developed.

Although in most surveys of Indian school children the maximum incidence of active disease is found in first graders, it is sometimes found in second and third graders. The latter suggests school transmission but cannot be said to prove it since the home environment has continued to exert its influence. In studies on the Apache reservation made with Forster, preschool children at 7-Mile Canyon were found to have a trachoma index of 33.4 per cent, and school children an index of 34.3 per cent. In contrast, Canyon Day preschool children had an index of 14.4 per cent and school children an index of 26.2 per cent. In his 1963 study of the Pima community of Blackwater, Foster found in a house-to-house canvas that active disease was limited almost entirely to the children of preschool and school age and that the maximum prevalence was in the 8-year-old group.

The common use of cosmetics for beautification of eyelashes has interested our virus study group by virtue of an epidemic of follicular conjunctivitis, 90 per cent of it in girls, at a San Jose High School. In this epidemic it was found that girls too young to obtain their parents' permission to use cosmetics were borrowing cosmetic pencils from older girls and sharing them freely. I have inquired into this problem in the Indian boarding schools, but so far have been unable to trace any spread of trachoma from this practice. School nurses and physicians have been alerted to its danger, however.

Epidemiologic patterns of trachoma in the United States

Even before the development of effective antitrachoma treatment (the sulfonamides, 1938), trachoma was declining in the white population of the United States. This decline could be attributed in part to the detection and treatment campaigns of the U. S. Public Health Service in the states of the "trachoma belt" but was due probably in greater part to the improvement in the economic and educational levels of the affected populations. It has long been known that even a minor rise in the socioeconomic level of a population affected by trachoma results in a significant decrease in the disease. With the introduction of the sulfonamides, and later the antibiotics, the treatment campaigns in such states as Illinois, Missouri, and Arkansas became remarkably effective so that trachoma in those states is now limited to occasional sporadic cases.

In 1938 a sulfanilamide-treatment program was instituted by the Indian Service, and enjoyed remarkable success. Unfortunately it had to be discontinued with the onset of World War II before its full potentiality had been realized. The results were summarized by Forster and McGibony. They show a striking drop in the prevalence of active trachoma in the various Indian areas treated. In this costly campaign, which required the services of physicians specially trained in trachoma control, assisted by a corps of special trachoma nurses, the Indian schools were covered thoroughly. Although a sizeable
segment of the adult population was also treated, the coverage was insufficient to prevent a recrudescence of the disease when treatment was abandoned. Except in the tribes of the southwest, however, trachoma has never again become a problem.

In the southwest tribes such as the Navajo, Apache, Pima, and Papago, the prevalence of trachoma returned approximately to its prewar level. The epidemiologic features of the disease in the desert areas which favored this return to a high index included, in order of relative importance, (1) desert conditions with poor water supply, (2) poor personal hygiene, (3) seasonal bacterial conjunctivitis, and (4) flies. Since the war, the treatment program has been limited, except for outpatient and hospital cases, to school children. Lack of funds and personnel has prevented coverage of the adult and preschool populations. As a result, too many trachomatous children, treated successfully while in school, have returned to their families to be reinfected during the summer months. To control such reinfection, strenuous efforts are now under way to develop a vaccine. In the absence of an effective vaccine, or of an effective short-term method of treatment, it would seem that trachoma can be eradicated in the southwestern United States only by (1) treatment of a large percentage of affected adults, (2) control of seasonal conjunctivitis, (3) control of flies, and (4) prompt detection and treatment of affected individuals.

The epidemiology of sporadic cases

Epidemiologic study of sporadic cases of trachoma that are apparently unrelated to familial infection or to known foci of the disease has for the most part been unrewarding. If the claims of Jones and his co-workers were correct, one could postulate that most sporadic cases arise from so-called "genital trachoma" or, in other words, from inclusion urethritis or cervicitis. In the past, unchlorinated swimming pools and public baths have been the chief sources of inclusion conjunctivitis of the adult. A few cases of autotransmission of the disease have also been reported. Unfortunately these cases have not been well documented, but I feel sure from personal observation that autotransmission accounts for a few cases just as it accounts occasionally for an adult case of gonococcal conjunctivitis. In our experience it has always been possible to distinguish clinically between these cases of inclusion conjunctivitis and trachoma by virtue of their benign course, their rapid response to treatment, and above all their failure to develop pannus.

Recently we have tested a strain of inclusion conjunctivitis virus (IC Cal 3), obtained from a typical case of inclusion conjunctivitis of the newborn, on a human volunteer, Mr. Ameil Bordi, who is blind from retinitis pigmentosa but has normal corneas and conjunctivas. The first inoculation resulted in a clinically typical inclusion conjunctivitis of the right eye without scar formation or pannus during the 2 months before the disease was interrupted by chemotherapy. Since then, 5 additional inoculations with the same agent have been made in the same eye. Disease has resulted in each instance but has been somewhat modified in clinical appearance and course. There has been progressive shortening of the incubation period and of the clinical course to spontaneous healing. In none of the attacks did conjunctival scars or pannus develop.

The results of this inoculation experiment in man with a typical inclusion conjunctivitis strain, coupled with the failure of any of our swimming pool cases of inclusion conjunctivitis to develop pannus or scars, and with the failure to demonstrate trachoma in the families of any of our numerous cases of inclusion conjunctivitis of the newborn, make it seem very unlikely that Jones's concept of the identity of trachoma and inclusion conjunctivitis is correct. It is significant, moreover, that the epidemiologic patterns of in-
clusion conjunctivitis and trachoma in the United States differ in all important respects. In spite of many efforts to uncover the disease, no cases of inclusion conjunctivitis of the newborn (inclusion blennorrhea) have been reported in our Indian population. Conversely, we have not found a single case of trachoma in our large local Negro population which furnishes over half of all our local cases of inclusion conjunctivitis.

It may be of interest to refer to the history of the clinically dissimilar diseases, herpes zoster and varicella, whose etiological identity was suspected on epidemiologic grounds long before the etiological agent was cultivated. Nothing comparable to the zoster-varicella epidemiologic relationship ever has been observed in connection with trachoma and inclusion conjunctivitis. It is also of interest that Lindner, who initially advanced the "genital trachoma" concept, completely reversed his opinion on the basis of the invariably benign course of inclusion conjunctivitis.

The failure of the laboratory to differentiate strains of trachoma virus from inclusion conjunctivitis virus only emphasizes our lack of knowledge of the whole PLT group of agents in which strain differentiation can as yet be established only on the basis of biologic testing in host animals or man.

Discussion

The epidemiologic patterns and the gravity of trachoma are known to differ somewhat from area to area throughout the world. It is not known whether these variations in any way depend upon strain differences, however, although strain differences are now known to exist. For example, the BOUR strain, isolated from a case of acute trachoma in San Jose, has consistently produced severe disease in both monkeys and man. A number of other trachoma strains (e.g., the T'ang strain) have lost their ability to induce disease in monkeys and man. Still others are infective for monkeys but produce mild disease only.

In the United States, trachoma of the white population has in general been severe in type, and independent of bacterial infection for transmission. Trachoma in the American Indian, on the other hand, has in general been relatively mild and has often been associated with secondary bacterial infection, particularly in the southwest. American trachoma isolates now include both "white" and "Indian" strains and it is hoped that future studies will reveal significant strain differences that may have epidemiologic significance.

The epidemiology of sporadic cases in the United States is of particular interest in view of the revival by Jones of Lindner's discarded concept of "genital trachoma." In this connection it is of interest to refer to the now well studied BOUR strain isolated from a white mechanic in San Jose who had no trachoma in his family and no known contacts with the disease. It was suggested by several workers to whom this strain was sent that it might represent an inclusion conjunctivitis of genital origin. The patient had no history of urethritis, however, and none of his three young children had had ophthalmia neonatorum. The development of keratitis and pannus early in the disease ruled out, in my opinion, the possibility of inclusion conjunctivitis, which in the United States never develops pannus. The discovery of a small but definite focus of trachoma (37 cases) in the Mexican population of San Jose, as well as the identification of 3 additional cases of typical active trachoma in the white and oriental populations of the area, indicate that opportunity for exposure to trachoma did in fact exist in the patient's environment. In none of our studies have we uncovered a case of trachoma in a family in which there was a case of inclusion conjunctivitis of the newborn, nor has trachoma ever evolved from a case of infant or adult inclusion conjunctivitis in my now large series of personal observations that has extended over a period of 30 years.
REFERENCES

2. Sory, R.: Personal communication.