Rheumatic heart disease remains the only completely preventable affliction of the heart. While rheumatic fever and rheumatic heart disease have substantially disappeared from affluent Western society, a recent outbreak of acute rheumatic fever in Utah is at odds with this trend. These diseases remain major causes of death and disability in third world countries. This can only mean that the available means of prevention are not being applied in these areas. For this reason, the experience gained in primary prevention efforts in the United States when rheumatic heart disease was a significant health problem may well have global application. Because the northern Rocky Mountain region was known as one of the three high-risk areas in the United States, the largest and most sustained primary prevention programs were centered here.

First attacks of rheumatic fever are prevented by detecting and treating cases of streptococcal pharyngitis before the rheumatic process has begun. Treatment is relatively simple, but diagnosis presents problems for several reasons:

- Diagnosing streptococcal pharyngitis definitively is not practicable, since it rests on showing rising antistreptococcal antibody titers over a period of several weeks.\(^4\)
- Diagnosing clinically on the basis of symptoms and signs is impossible: even in the best hands, these are not reliable indices.\(^3\)
- A presumptive diagnosis is the best that current techniques can provide. Such a diagnosis may be assumed when a culture is positive in the presence of any symptoms or signs of pharyngitis, but many such cases will actually represent carrier states.\(^4\)

In the conventional or “practice” setting, preventing first attacks of rheumatic fever would require that every case of streptococcal pharyngitis generate symptoms sufficiently severe to prompt a visit to a physician, that every physician use a throat culture to establish a diagnosis, and that treatment be always adequate. As a matter of practical experience, this chain of events is not the rule.

As Massel and co-workers pointed out,\(^5\) the symptoms of streptococcal pharyngitis preceding documented rheumatic fever are often so mild the victim never brings them to anyone’s attention. Simple inquiry reveals that many parents treat pharyngitis by giving aspirin or throat lozenges, and in the 1950s and 1960s, a distressing number of physicians did not know the proper treatment for streptococcal pharyngitis.\(^6\)

In the period 1950-1970, a number of investigators, recognizing these inadequacies in conventional health care delivery, organized programs of mass surveillance and treatment among schoolchildren, the group at highest risk of rheumatic fever. All programs were based on the concept of a liberal use of throat cultures in children with symptoms or signs of pharyngitis, together with vigorous attempts to ensure appropriate treatment.

The first successful sustained large-scale program of this type was organized in 1954 in Casper, Wyoming; the same protocol was later implemented throughout the state. The design of the program was simple: every morning in every schoolroom, teachers asked the children if any had symptoms of a “cold” or sore throat. Those admitting symptoms were directed to a central station where throats were inspected and specimens were taken for cultures. Later experience showed that many children had florid signs of pharyngitis without symptoms. To detect this group, one row from each schoolroom was inspected daily for signs of pharyngeal inflammation. Children having a positive culture in
the presence of symptoms or signs of pharyngitis were excluded from school until treatment had been started or, in cases where religious convictions precluded treatment, until a culture was reported negative. This exclusion was legally enforceable because streptococcal pharyngitis is a reportable, excludable disease in every public health code.

Similar programs were later organized in Fort Collins, Colorado, by Jackson and colleagues; in the Sangre de Cristo school district of southern Colorado; among Alaskan natives by the streptococcal section, ecological investigations division, Centers for Disease Control (CDC); and among the Navajo and Papago tribes of Arizona by the University of Arizona Medical Center, Tucson. The protocols in all were in essence the same, based on an aggressive search for streptococcal infection in schoolchildren populations, with a maximal effort to treat those found to be infected.

Methods

The laboratory methods used in all projects were essentially the same, with incubation of sheep's blood agar in a carbon dioxide-enriched, seminaerobic atmosphere. Grouping was carried out initially by the weak-bacitracin-disc method and later by an immunofluorescent-antibody technique. In the Casper program, school nurses did the throat swabbing; later, a large number of mothers were recruited from Parents and Teachers Associations and trained in physicians' offices in the techniques of inspecting the pharynx and obtaining a specimen for throat culturing. This was the first widespread use of paramedical personnel in the United States and it proved very successful. Not only did the volunteers acquire professional levels of skill in inspecting and swabbing the pharynx, but the educational effect of this training throughout the community was a major benefit of the program. In the CDC programs, both professional and volunteer help was used in obtaining specimens for throat cultures. Standard American Heart Association recommendations for treatment were followed throughout. In the Casper program, treatment was legally required; in others, it was strongly urged, resulting in a high level of compliance.

Results

The results of such programs may be assessed on the bases of their effect on the incidences of streptococcal infection and of new cases of rheumatic fever.

The Level of Streptococcal Infection

The effect of the programs on the incidence of streptococcal infection can be evaluated in three ways:

- Documenting streptococcal isolation rates compared with those of a control group.
- Studying antistreptococcal antibody titers compared with those of a control group.
- Studying streptococcal isolation rates throughout the period of surveillance as compared with the expected seasonal levels established by studies in schoolchildren.

The Casper program was started in 1954 and by 1957 had expanded to include all Natrona County schools. By 1960 considerable experience had been accumulated, techniques had been standardized, and the laboratory had improved performance with the assistance of staff from the University of Colorado Medical Center.

In 1964 the Centers for Disease Control group set up epidemiologic studies in two Colorado communities to establish streptococcal prevalence rates. By 1969 consistent patterns in terms of isolation rates and antibody profiles had been recorded; thus, a "control" group was available.

In 1965 the CDC group visited Natrona County on two occasions during the school year, obtaining throat specimens for culture and blood specimens for antibody study from randomly selected groups of schoolchildren. The results of this study proved that the surveillance and treatment program had had a dramatic effect on levels of streptococcal infection. The isolation rate of 1.3% recorded by the CDC workers was the lowest ever recorded in a temperate-zone schoolchildren population, contrasting strikingly with the levels of 15% to 30% recorded during the same period in the Colorado schoolchildren. Continuing comparison of isolation rates throughout the school year with frequent cross-checks of cultures in the two laboratories to ensure comparable results showed an isolation rate in the Colorado children fivefold to sixfold the level in the Casper children at all times (Figure 1). In addition, antibody profiles showed a very low level of current and antecedent infection in the Casper children as compared with the Colorado schoolchildren.

Subsequently, the CDC group instituted a similar program in the Sangre de Cristo school district of southern Colorado, with a reduction of prevalence rates to 4.5% as compared with levels of 21.9% recorded by the same group in other Colorado communities (Figure 2). A substantial "carryover" effect was recorded with lower levels of isolation rates in children at the beginning of the second year of the study. Zimmerman and CDC associates were able to reproduce these results in Alaskan native villages, even under the handicap of remoteness from laboratory facilities and serious logistic problems. Jackson implemented surveillance-treatment programs in schoolchildren in Morgan
throughout the school year. The initial levels. The same results, involving intensive surveillance and treatment programs can alter the “total streptococcal milieu” in a favorable manner. Even a loosely organized project by Hubbard and co-workers produced a significant fall in identification rates in Philadelphia schoolchildren. These workers failed to recognize the significance of their own results and fell into the trap of trying to differentiate carrier states from active infections by the appearance of the pharynx, a notion refuted by their own subsequent antibody studies.\(^\text{13}\)

**Occurrence of New Cases of Rheumatic Fever**

The effect of the programs on the occurrence of first attacks of rheumatic fever is much more difficult to record for several reasons. First, reporting by physicians to public health authorities is notoriously poor. In Colorado investigators found that only 15% to 20% of cases were being reported to the state.\(^\text{14}\) Overdiagnosis and errors in diagnosis are common.\(^\text{15}\) Second, as often as not, rheumatic fever is insidious; streptococcal infections are followed by rheumatic heart disease without overt clinical rheumatic fever in about 50% of all cases.\(^\text{16}\) With these limitations in mind, the following estimates can be made:

- In Natrona County, the Asian influenza epidemic of 1957 was followed by recurrent epicenters of streptococcal infection that erupted for almost two years. At that time the school surveillance program was in effect, but the culture and treatment facilities had not involved the remainder of the population. The streptococcal epidemic was followed by an epidemic of acute rheumatic fever that persisted with remissions and exacerbations until the end of the 1959 school year. In a three-year period there were 25 new cases of acute rheumatic fever among the non-schoolchildren population of the county; among the schoolchildren, there were 4.\(^\text{17}\) The significance of this difference is heightened by the fact that in normal circumstances, 85% of new cases of rheumatic fever occur in schoolchildren during the school year.\(^\text{17}\)
- The Papago tribe of Arizona is a closely knit ethnic group of 13,000 living in a remote desert area. Nothing in the style of living of the tribe changed in the years 1973 to 1980, in...
and the only change in health care delivery was the institution of the surveillance program. The fall in the number of new cases of rheumatic fever to 0 in 1978 from the high of 12 in 1970 and the previous six-year average of 6 per year may therefore reasonably be attributed to the control program.

- Gordis recorded a significant fall in the incidence of new cases of rheumatic fever when intensive medical management was introduced to inner-city populations in Baltimore. This program included intensive surveillance and treatment projects directed at schoolchildren.

**Wyoming Statistics for the Period 1973-1982**

Because the Wyoming control program was the only project that applied the surveillance measures described above to an entire state, the statistics available to the state health department are of some interest. Identification rates recorded by hundreds of workers in different communities cannot be compared, since they probably reflect the enthusiasm or discrimination of the various workers as much as a difference in prevalence. The total percentage, however, of positive cultures by months between the years 1963-1964 and 1982-1983 confirms the reversal of the expected seasonal fluctuation of streptococcal prevalence, with a consistent fall in rates throughout the school year and overall levels below any recorded control group (Table 1).

A regression analysis between years and number of reported cases of rheumatic fever per 100,000 population was carried out for Casper-Natrona County and for the rest of the state of Wyoming outside Natrona County. Over a ten-year period of the Rheumatic Fever Registry (1973-1982), the incidence of rheumatic fever declined statistically for both Casper-Natrona County \( (f[1,8] = 5.98, P = .0402) \) and the rest of Wyoming \( (f[1,8] = 46.62, P < .0001) \). A natural log transformation was done to take into account the curvilinear nature of the declining rate in rheumatic fever incidence. During this ten-year period, an average of 1.7 cases of rheumatic fever was reported per 100,000 population per year for Casper-Natrona County. The rest of Wyoming, however, reported an average of 6.4 cases per 100,000 population per year for the same period.

The incidence of rheumatic fever was consistently lower for Casper-Natrona County than for the rest of Wyoming during this ten-year period. There were no reports of rheumatic fever for Casper-Natrona County for 1980, 1981, and 1982. By 1982, the incidence for the rest of Wyoming was only 0.7 cases per 100,000 population (Figure 4). (Through 1985, the incidence of acute rheumatic fever has stabilized at zero for Casper-Natrona County while three to four cases per year were reported for the rest of Wyoming [case rate 0.7 to 1.0 per 100,000 population per year].) The nationwide decline in the occurrence of rheumatic fever through this same period and the unreliability of reporting by physicians make these figures more difficult to assess, but the difference between Casper-Natrona County and the rest of the state appears significant.

**Discussion**

The results produced by a number of different investigators confirm the possibility of altering the total streptococcal milieu in a favorable manner by programs of intensive surveillance and treatment. The near disappearance of acute rheumatic fever from the affluent western world while the disease persists in a virulent form and at high levels among underserved populations speaks strongly for the effectiveness of modern diagnosis and treatment and for applying these techniques, in some manner, to populations at risk. The extremes of poverty in many parts of the globe make it unlikely that the private practice paradigm of western medicine will be available for a long time, if ever. Organized programs of control such as those described here may play an important role in certain specific settings.

Prompt diagnosis and treatment may also help to account for the diminished virulence of the streptococcus in western society through diminished opportunities for animal passage.

The Natrona County, CDC, and Morgan County projects all discovered and documented the importance of surveillance by inspection or culturing of a significant number of the asymptomatic children in any organized control program. The common occurrence of signs of pharyngeal inflammation without symptoms came as a surprise to the workers in all projects.

Without question, the educational impact of such programs is a major benefit. When parents are familiar with the

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Figure 4.—The graph shows reported cases of rheumatic fever per 100,000 population for Wyoming and Casper-Natrona County, 1973-1982. —— = state of Wyoming without Casper-Natrona County, ——— = Casper-Natrona County
sequelae of streptococcal infection and when they are prepared to insist on adequate diagnosis and treatment, the conquest of rheumatic fever is simply a matter of time, financing, and medical logistics.

REFERENCES


