Factors Affecting Streptococcal Colonization Among Children in Selected Areas of Alaska

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SEQUELAE OF STREPTOCOCCAL INFECTION are important public health problems in the developing countries of the world (*1–3*). Of these well-recognized diseases, rheumatic heart disease is of particular concern for both medical and financial reasons. Because of this concern and because rheumatic heart disease is potentially preventable, much emphasis is placed on primary prevention.

Most Alaskan Eskimos live in regions that are similar in many respects to a developing country. The lifestyle of the people in these areas is predominantly one of subsistence. Roughly 80 percent of these Eskimos live in small, isolated villages along the coast of the Bering Sea and inland along the western rivers. Because there are few physicians in these villages, community health aides have been trained to provide primary health care to the villagers. As substitute physicians, the community health aides emphasize clinical care, health education, and prevention.

During a 15-year period ending in the early 1970s, an average of 30 cases of acute rheumatic fever were diagnosed each year for Alaskan Natives. For patients aged 5–19 years who met the revised Jones criteria, the overall average annual rate for Eskimos in this age group living along the western coast was 84 per 100,000 population. Because treatment of each case of rheumatic heart disease was estimated (in 1971 dollars) to cost the health-care system between $50,000 to $75,000 on the average, prevention efforts seem to be the most cost-effective approach (data from Kenneth J. Fleshman, MD, Chief of Pediatrics, Alaska Area Native Health Service).

To deal with the problem of rheumatic heart disease, a streptococcal control and prevention program for Eskimo children in western Alaska was established in 1971 by the Center for Disease Control, the Alaska Area Native Health Service, and the Alaska Federation of Natives. The program was in effect for 5 years, from 1971 to 1976. Various aspects of this program were reported earlier (*4–6*). The purpose of the program was to control streptococcal infection, prevent its spread, and obtain additional information on the epidemiology of streptococcal disease. One aspect of the program was an investigation of the association between a number of possible risk factors and the prevalence of streptococci among Eskimo children.

Methods

For purposes of political, social, and medical administration, Eskimo villages in western Alaska are divided into three geographic regions: Norton Sound, Yukon-

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Table 1. Population of children in study villages of each region

Village	Number of children per age group (years)				Total
	3–6	7–9	10–12	13–18	
Norton Sound:					
St. Michael	5	17	18	9	49
Stebbins	18	18	20	10	66
Unalakleet	21	37	45	28	131
Yukon-Kuskokwim:					
Atmautluak	3	16	13	7	39
Kasigluk	7	26	29	11	73
Nunapitchuk	24	29	22	30	105
Bristol Bay:					
Manokotak	22	29	23	11	85
Togiak	28	39	32	38	137
Twin Hills	0	9	7	5	21

Kuskokwim, and Bristol Bay. Three villages from each of these regions were chosen for the control and prevention project. Each is characteristic of its geographic region, and each has had reported cases of rheumatic fever. In these villages, 1,099 children were 3–18 years (the age group considered to be at highest risk for rheumatic fever).

Since earlier investigators (*6*) found that the prevalence of streptococci in years 2–5 of the study was similar but different from the prevalence in year 1 (indicating that the program began to reach full effectiveness by year 2), our focus in this report is on the effect of risk factors observed in year 1 on the prevalence of streptococci in year 2. The data collected for 706 children aged 3–18 years with complete records from years 1 and 2 were considered for further analysis. Table 1 shows the age distribution of these children by village and region.

Data were collected by means of long-term surveillance techniques, similar to those tried in the Rocky Mountains of the United States (*7,8*). Community health aides collected swabs for throat cultures from each patient who was seen in the clinic and had symptoms of streptococcal pharyngitis. In addition, children from each village were divided into four groups similarly distributed by sex and grade in school. Children from the same family were placed in different groups if possible. While school was in session, the health aides collected specimens for cultures from members of one of the four groups of children each week. These specimens were collected without regard to symptoms so that every child would have had a specimen taken for throat culture at least once every 4 weeks. Asymptomatic children were not under surveillance during the summer when school was not in session.

Throat swabs were placed in silica gel and mailed to central laboratories in Anchorage or Bethel for processing. Beta hemolytic streptococci grown in pour plates were grouped by bacitracin sensitivity and Lancefield precipitation methods. Group A isolates were typed by T-agglutination and M-precipitation methods (*9*). Each week the laboratory reported positive results to the community health aide by telephone, radio, or teletype. Children with group A streptococci were treated with benzathine penicillin. When an important epidemic trend within a village was apparent, all the children included in the program were placed on a prophylactic regimen of benzathine penicillin (*10*).

The investigation of the effect of several important and identifiable risk factors on the prevalance of streptococci was accompanied by an analysis of information obtained during the 2 consecutive years of the study (1971–72). Data collected by year included age and sex of each child, number of children in each household, proportion of throat cultures positive for streptococcal organisms, and the health-aides' rating. Health aides from each village were rated by a team of physicians and nurses who taught the aides how to conduct the program and who visited periodically to monitor performance or investigate epidemics. The ratings were based on the health aide's overall performance in effectively promoting good hygiene, providing general health care, and managing daily specimen culturing and treatment activities. Special attention was given to the aide's management of the program, that is, his or her expediency in handling the throat swabs (minimizing the time required between taking of swab and mailing) and his or her expediency in administering treatment to children with confirmed positive cultures.

We used a multiple-regression model (*11,12*) to examine the data on the 706 children selected for analysis. Using the rate of positive throat cultures (colonization rate) during the second year for each child as the dependent variable, we considered the effects of six independent variables or factors: age, sex, number of children in household, region, health-aide rating, and colonization rate for each child the first year. Each factor was subdivided into classes of investigative interest and partitioned so that each class contained a meaningful number of observations. The classes then were expressed by means of categorical variables in the multiple-regression model.

Results of the regression analysis were used to obtain adjusted colonization rates for each category or class of every factor (*13*). Adjusted rates provided a standardized colonization ratio, which measured the risk of being in a particular class of a given factor, while the effects of all other specified factors were held constant. The standardized colonization ratio for a given factor and class was defined as the percentage of the corresponding adjusted rates to the overall crude colonization rate.

Results

In examining the effects of the six previously mentioned independent or explanatory variables, we found that age, health-aide rating, previous colonization rate, and health-care region were significantly associated with streptococcal colonization.

Table 2 shows the distribution of Eskimo children in the first year of the project with regard to the six risk factors selected, along with corresponding crude rates of streptococcal colonization for each class of each factor calculated for the second year. Of the 706 children studied, 353 had streptococcal organisms in at least 1 throat culture the second year, which indicates an overall crude colonization rate of 50 percent. An examination of crude rates per 100 children for the independent risk factors showed that age produces the most extreme variation—ranging from 32.9 for the age group 13–18 years to 62.5 for the age group 3–6 years. On the other hand, crude colonization rates for Eskimo boys and girls differed by only 1.4 percent, indicating only a small variation by sex.

Table 2 also shows adjusted rates of streptococcal colonization obtained from the regression analysis. The factors having the greatest significance or the greatest association with colonization rate in the second year were age, health-aide rating, and colonization rate the first year ($P < 0.01$), and of lesser significance, health-care region ($P < 0.05$). Note that the adjusted rates decrease with improved ratings of the health aide, as might be expected. Children who received care from health aides who were rated above average had an adjusted rate 31 percent lower than that for children cared for by aides who were rated below average.

Finally, table 2 shows the standardized colonization ratio for each class of a given factor, that is, an estimate of the percentage of overall risk that we would expect if every child in our population were in the same class of a given factor and the effect of the other risk factors were removed. The largest standardized colonization ratio was 122 percent for children 3–6 years old, and the smallest was 67 percent for children 13–18 years old.

Discussion

A binary variable multiple-regression model was used to assess the effect of several risk factors related to streptococcal colonization in a population of Alaskan Eskimos with a high annual incidence of acute rheumatic fever. The adequacy of the model for these data and its simplicity of computation and interpretation of results have made it the method of choice here over other more theoretically appealing but complicated models such as the multiple logistic one. Analysis by the multiple logistic model resulted in conclusions similar to those we have presented.

Our analysis indicates that four of the six independent risk factors contributed significantly to the prevalence of streptococcal colonization. There was a definite association between age and colonization, a relationship observed by other investigators (*14*).

Another factor strongly associated with colonization was the rating of community health aides. This association indicates the importance of good health care in controlling the spread of streptococcal organisms. Attributes associated with an above-average health-aide score included the expedient and careful handling of collected throat swabs and the efficient and effective administering of treatment to children found to have positive cultures. This health-aide rating reflects not only the health-aides' ability to do their daily job of promoting good hygiene and providing good medical care, but also their efficiency in minimizing the time between throat swabbing and treatment of children with positive results. Consequently, proper selection and training of health aides is crucial in a region where highly trained medical personnel are not immediately available. Standardized colonization ratios corresponding to health-aide ratings (table 2) indicate that the overall rate of streptococcal colonization might be reduced 25 percent if all villagers could receive above-average health-aide care.

The colonization rate for the first year had a highly significant association with later streptococcal colonization. This finding indicates that the same children tended to have positive throat cultures in both years.

One final factor somewhat less significantly associated was health-care region. The relationship of health-care region to streptococcal colonization may indicate the importance of geographic distribution of streptococcal organisms in this remote area of Alaska. This relationship could also reflect delays in processing cultures or reporting positive results as a result of the variables of transportation and communication in different regions.

The other two risk factors, sex and number of children in the household, were not significantly related to streptococcal colonization. Other investigators (*15, 16*) have reported similar findings with regard to sex. The conclusion that number of children in the household was not associated with streptococcal colonization agrees with similar findings reported from Ethiopia (*16*) regarding overcrowding in the home. Yazov and associates (*16*) observed that many Ethiopians live in well-ventilated huts and spend most of their day in the

Table 2. Distribution of children, second-year crude and adjusted rates of streptococcal colonization per 100 children, and corresponding standardized colonization ratios for various risk factors

Factor	*Number of children*	*Percent of total number of children*	*Crude rate*	*Adjusted rate*	*Standardized colonization ratio (percent)*
Overall	706	100.0	50.0	...	100
Age group (years):[1]					
3–6	128	18.1	62.5	60.9	122
7–9	220	31.2	57.7	57.3	115
10–12	209	29.6	46.4	47.3	95
13–18	149	21.1	32.9	33.6	67
Sex:					
Male	359	50.8	49.3	48.7	97
Female	347	49.2	50.7	51.3	103
Number children in household:					
1	69	9.8	43.5	47.6	95
2–3	289	40.9	46.0	46.6	93
> 4	348	49.3	54.6	53.3	107
Health-care region:[2]					
Norton Sound	246	34.8	45.1	43.8	88
Yukon-Kuskokwim	217	30.7	51.2	57.1	114
Bristol Bay	243	34.5	53.9	49.9	100
Health-aide rating:[1]					
Below average	310	43.9	55.5	54.6	109
Average	302	42.8	47.7	49.1	98
Above average	94	13.3	39.4	37.6	75
Colonization in first year:[1]					
No	288	40.8	41.7	42.8	86
Yes	418	59.2	55.7	55.0	110

[1] Chi-square test on adjusted rates yields $P < 0.01$.

[2] Chi-square yields $P < 0.05$.

open air. On the other hand, Eskimos spend long periods indoors in an overcrowded environment at home, at school, and at other community gathering places. Additional children in the home contributed little to the almost universal overcrowding and hence did not appear to affect the risk of streptococcal colonization.

One final and yet highly important application of our multiple-regression model is in describing the conditions under which a child is at greatest risk of being colonized by streptococci. Children at the greatest risk were in the age group 3–6 years, had a history of streptococcal colonization, and lived in a village receiving below-average health-aide care in the Yukon-Kuskokwim health care region. Risk of colonization for such a child was 82 percent. An estimate of risk such as this can be particularly useful in planning for effective and economical disease prevention and control.

References

1. Padmavati, S.: Rheumatic fever and rheumatic heart disease in developing countries. Bull WHO 56: 543–550 (1978).
2. World Health Organization: Recent advances in rheumatic fever control and future prospects: a WHO memorandum. Bull WHO 56: 887–912 (1978).
3. Vaughan, J. P.: A review of cardiovascular diseases in developing countries. Ann Trop Med Parasitol 72: 101–109 (1978).
4. Bender, T. R., et al.: Streptococcal surveillance in remote Arctic populations: the development of a system for detection of group A pharyngitis and the prevention of nonsuppurative sequelae. Acta Socio-Med Scand [Suppl] 6: 240–248 (1972).
5. Zimmerman, R. A., et al.: Streptococcal surveillance and control in Alaska natives. Proceedings of the Fifth International Symposium on *Streptococcus pyogenes*. Amsterdam, Holland, August 1972.
6. Bender, T. R., and Brant, L. J.: Streptococcal surveillance in remote Arctic populations: the development of a system for the prevention of acute rheumatic fever. Paper presented at IVth International Symposium on Circumpolar Health. Novosibirsk, USSR, October 1978.
7. Phibbs, B., Taylor, J., and Zimmerman, R. A.: A community-wide streptococcal control project: the Natrona County primary prevention program, Casper, Wyoming. JAMA 214: 2018–2024 (1970).
8. Zimmerman, R. A., et al.: An effective program for reducing group A streptococcal prevalence. Pediatrics 48: 566–572 (1971).
9. Wilson, E., Zimmerman, R. A., and Moody, M. D.: Value of T-agglutination typing of group A streptococci in epidemiologic investigations. Health Lab Sci 5: 199–207 (1968).
10. Zimmerman, R. A., Cross, W. M., and Miller, D. R.: A streptococcal epidemic in an isolated civilian population with institution of mass prophylaxis. J Pediatr 69: 40–45 (1966).
11. Suits, D. B.: Use of dummy variables in regression equations. J Am Stat Assoc 52: 548–551 (1957).
12. Feldstein, M. S.: A binary variable multiple regression method of analyzing peri-natal mortality and other outcomes of pregnancy. J Royal Stat Soc, Series A 129: 61–73 (1966).
13. Shah, F. A., and Abbey, H.: Effects of some factors on neonatal and postneonatal mortality: Analysis by a binary variable multiple regression method. Milbank Mem Fund Q 49: 33–57 (1971).
14. Breese, B. B., and Hall, C. B.: Beta hemolytic streptococcal diseases. Houghton Mifflin Company, Boston, 1978, pp 48–49.
15. Dingle, J. H., Badger, G. F., and Jordan, W. S.: Illness in the home. A study of 25,000 illnesses in a group of Cleveland families. Western Reserve University Press, Cleveland, 1964, p 103.
16. Yazov, L., Petros, W. G., and Stump, E.: Epidemiological studies on rheumatic heart disease and streptococcal carriers among school children in Addis Ababa, Ethiopia. Z Rheumatol 37: 304–308 (1978).

SYNOPSIS

BRANT, LARRY J. (National Institute on Aging, Baltimore City Hospitals), BENDER, THOMAS R., and MARNELL, RICHARD W.: *Factors affecting streptococcal colonization among children in selected areas of Alaska. Public Health Reports, Vol. 97, September–October 1982, pp. 460–464.*

The epidemiology of streptococcal disease affecting 706 Alaskan Eskimo children was investigated by analysis of data on throat cultures obtained during a long-term surveillance program begun in 1971. A binary variable multiple-regression model was used to study the association between streptococcal colonization of these children and six potential risk factors: age, sex, number of children in household, region, health-aide rating, and colonization rate for each child the previous year. Factors found to be significantly associated with streptococcal colonization included age, past colonization, competence of local health-aide in providing care, and health-care region. Age varied most in the standardized colonization ratio (percentage of corresponding adjusted rate to overall crude colonization rate), ranging from 122 percent for children 3–6 years old to 67 percent for children 13–18 years old.

The number of children in overcrowded homes and a child's sex were not apparently important. The method of analysis can be used to provide health-care planners with a simple means of identifying potentially important areas of concern for planning effective and economical health-care strategy.