Bacterial Meningitis in Navajo Indians

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DESPITE THE AVAILABILITY OF ANTIBIOTICS, bacterial meningitis still results in appreciable morbidity and mortality (*1,2*). Bacterial meningitis due to *Haemophilus influenzae* has actually increased during the antibiotic era (*3–5*). The incidence of bacterial meningitis varies by age, sex, social class, ethnic origin, and other characteristics in different population groups (*5–9*). A national study based on death certificates suggested that American Indians are especially susceptible to *H. influenzae* meningitis (*10*). To test this observation, we examined the epidemiology of bacterial meningitis in one group of American Indians, the Navajo.

Methods

The Navajo, the largest tribe of American Indians, live on a 25,000-square-mile reservation on the high Colorado Plateau in Arizona, New Mexico, and Utah, and in towns bordering the reservation. Seven Public Health Service hospitals on or near the reservation and one private hospital under contract with the Public Health Service provide inpatient medical care for virtually all the Navajo in the area studied. A second small private hospital on the reservation has certain inpatient facilities and was included in the study, but it does not provide care for seriously ill patients. Few Navajos use any other inpatient facilities because of distance and transportation problems, and because the Public Health Service provides services free to all Indian beneficiaries.

Medical records at the nine hospitals serving the Navajo were examined if they specified a discharge diagnosis of bacterial meningitis made during the 5-year period July 1, 1968, through June 30, 1973. The following data were collected from each record: etiology, method and date of diagnosis, tribal affiliation, age and sex of the patient, location of the patient's residence, and outcome of the case. A diagnosis of bacterial meningitis was counted as a case only if it was confirmed by culture of an organism from cerebrospinal fluid. Patients with diagnosis based on organisms observed in gram-stainable material or pleocytosis in cerebrospinal fluid were excluded from this study.

The 1970 census of the United States estimated the Navajo population to be 96,743, but this figure is deemed inaccurate by both the Navajo Tribe and the U.S. Bureau of Indian Affairs (BIA) because of the difficulty in locating the Navajos, many of whom live in camps scattered over a large area of rough terrain, during the formal census period. The BIA makes an independent census based on birth and death certificates, school records, and enrollment for tribal benefits or programs. On the basis of the BIA census, the estimated population of the Navajo Tribe in January 1972

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Table 1. Number of cases and mean yearly incidence of bacterial meningitis among the Navajo, by etiology, July 1968–June 1973

Etiological agent	All ages		Under 5 years	
	Total number of cases	Annual rate per 100,000	Total number of cases	Annual rate per 100,000
Haemophilus influenzae	122	17.7	121	173.1
Diplococcus pneumoniae	55	8.0	40	57.2
Neisseria meningitidis	14	2.0	10	14.3
Mycobacterium tuberculosis	14	2.0	7	10.0
Miscellaneous	14	2.0	12	17.2
Total	219	....	190	....

Table 2. Number of cases of bacterial meningitis among the Navajo, by etiology, age, and sex, July 1968–June 1973

Etiological agent	Age (years) and sex							
	Under 1		1–4		5–15		Over 15	
	Male	Female	Male	Female	Male	Female	Male	Female
Haemophilus influenzae	48	46	7	20	0	0	0	1
Diplococcus pneumoniae	25	10	4	1	1	2	8	4
Neisseria meningitidis	4	3	1	2	0	1	1	2
Mycobacterium tuberculosis	0	0	2	5	0	0	2	5
Total	77	59	14	28	1	3	11	12

was 135,852. By including the Indian population of towns adjacent to the reservation and assuming a 2 percent annual increase in population, we estimated that at the midpoint of the period covered in this study (January 1, 1971) 137,820 Navajo people were being served by the hospitals surveyed. The proportions in age subgroups were determined by use of the BIA January 1972 estimates, as well as data compiled from birth certificates (*11*). These figures served as denominators for calculations in this study.

Results

A total of 219 cases of bacterial meningitis proved by culture of cerebrospinal fluid were on record in the 9 hospitals for the 5-year period (table 1). *H. influenzae* was the most common etiological agent, more frequent that all other pathogens combined. All but one of the patients with *H. influenzae* meningitis and nearly three-fourths of the patients with pneumococcal and meningococcal meningitis were under 5 years of age. Of the 14 patients with meningitis due to *Mycobacterium tuberculosis,* only half were in that age group.

One case of apparent dual infection with *H. influenzae and Diplococcus pneumoniae* (not counted elsewhere) was included in the category of miscellaneous etiological agents. Organisms isolated from the cerebrospinal fluid of the remaining 13 patients in this category were: *Escherichia coli,* 3; *Klebsiella-Aerobacter* group, 3; beta-hemolytic streptococcus, 2; *Pseudomonas,* 1; *Proteus,* 1; *Staphylococcus,* 1; *Streptococcus viridans,* 1; and anerobic streptococcus, 1. Eleven of the 13 patients were 18 months old or younger, including 9 under 6 months and 4 under 1 month.

As shown in table 2, there was a large concentration of cases of *H. influenzae,* pneumococcal, and meningococcal meningitis during the first year of life. The incidence of *H. influenzae* and pneumococcal meningitis for children under 1 year was particularly impressive. The annual rates per 100,000 population at risk were 550 and 200, respectively, based on the BIA count of 3,425 Navajo children in this age group. Although there was a male predominance of approximately two to one in cases of pneumococcal meningitis, there was no overall consistency in sex ratios for patients with *H. influenzae* meningitis.

There was considerable seasonal variation for pneumococcal meningitis among the Navajo people, with only 1 of the 55 cases occurring during July through September. There was less but still some fluctuation in cases of *H. influenzae* meningitis. About equal numbers occurred during April through June (22 cases) and July through September (20 cases), but there was a considerable increase during October through December (45 cases), followed by somewhat fewer cases during January through March (35). In summary, there was some clustering of *H. influenzae* meningitis cases during the autumn and winter and a notable absence of pneumococcal meningitis during the summer months.

Thirty-five deaths were recorded among the patients with bacterial meningitis: *D. pneumoniae,* 18; *H. influenzae,* 10; *Neisseria meningitidis,* 3; *M. tuberculosis,* 2; *Klebsiella-Aerobacter* group, 1; and *Proteus,* 1. Case fatality rates for the two most common etiological types were 33 percent for pneumococcal and 9 percent for *H. influenzae* meningitis. For patients under 16 years of age, the rates were 26 percent and 9 percent, respectively. Case fatality rates for those under 1 year were 24 percent for pneumococcal and 12 percent for *H. influenzae* meningitis. Because of the small numbers of cases, case fatality rates were not calculated for the other etiological agents.

The incidence of *H. influenzae* and pneumococcal meningitis among the Navajo was much higher than that found in other population groups studied recently (table 3) in Tennessee (*8*), South Carolina (*6*), New Mexico (*9*), and Minnesota (*5*). The incidence of

Table 3. Comparison of annual incidence of bacterial meningitis by etiology among the Navajo with that in other population groups

Population and date [1]	Annual rate per 100,000 population		
	Haemophilus influenzae	Diplococcus pneumoniae	Neisseria meningitidis
Navajos, 1968–73	17.7	8.0	2.0
Tennessee, 1963–71 (*8*):			
Rural	1.6	1.0	2.1
Urban (Nashville-Davidson County)	2.9	1.4	3.6
Charleston County, S. C., 1969–71 (*6*):			
Whites	2.2	0.9	2.1
Blacks	7.7	4.9	3.3
Bernalillo County, N. Mex. (including Albuquerque), 1964–71 (*9*)	3.7	1.4	0.8
Olmsted County, Minn. (including Rochester), 1959–70 (*5*)	4.3	2.3	1.3

[1] Numbers in parentheses are references.

meningococcal meningitis for the Navajo, however, did not differ much from that in the other groups. The relative stability of meningococcal attack rates is also indicated, incidentally, by the small variation in these rates between blacks and whites in Charleston County, S.C., in comparison with the differences in rates for *H. influenzae* and pneumococcal meningitis.

As shown in table 4, the age distribution of Navajo patients with *H. influenzae* meningitis contrasts rather sharply with the distribution among patients at the Childrens Hospital of Pittsburgh (*3*). Nearly 80 percent of the *H. influenzae* cases among the Navajo occurred during the first year of life, in comparison with about 40 percent (including only pediatric cases) in the Pittsburgh population. Few cases of meningitis due to *H. influenzae* were found among the Navajo children under 3 months or after 2 years of age. The situation was somewhat different for pneumococcal meningitis. More than 60 percent of the cases occurred during the first year, and 20 percent during the first 3 months of life. In Pittsburgh, there was less clustering of cases of pneumococcal meningitis among the very young. About 45 percent occurred in the first year and about 8 percent in the first 3 months, and these proportions would have been even smaller had adults been included in the Pittsburgh group as they were in the Navajo.

Table 4. Comparison of age distribution of patients with *H. influenzae* among the Navajo with that for children in Pittsburgh, Pa.

Age	Navajo (1968–73)		Pittsburgh, Pa. (1961–70)[1]	
	Number	Percent	Number	Percent
Under 1 yr.	94	78	155	41
Under 3 mo.	3	2	15	4
3–5 mo.	44	36	45	12
6–8 mo.	28	23	63	17
9–11 mo.	19	16	32	8
1 yr.	19	16	103	27
2 yr.	7	6	54	14
3 yr.	0	0	31	8
4 yr.	1	1	15	4
5–15 yr.	0	0	21	6
Total under 16 yr.	121	..	379	..

[1] Reference 3.

Discussion

The methods used in this study may have resulted in underestimates of the true incidence of bacterial meningitis among the Navajo. First, the use of hospital discharge diagnoses as the sole method of casefinding excluded cases in patients who were not hospitalized or whose disease was unsuspected during life. In a study of infant mortality among the Navajo in 1970, which used the same hospitals included in the present study, no hospital records could be found for approximately 7 percent (6 of 84) of the infants for whom there were death certificates. This implies that some infants are not hospitalized and die at home, and since post mortem examinations are not required, no definitive diagnosis is made for them. Likewise, post mortem diagnoses of bacterial meningitis were not used in this study because the Navajo rarely permit autopsies. Second, many cases excluded from this study may indeed have been bacterial in origin. The cerebrospinal fluid from some patients who were not included showed gram-stainable material considered to be bacterial or pronounced pleocytosis with a predominance of neutrophils, or both. In a few cases with septicemia and positive blood cultures, meningitis was also suspected, but these were excluded as well. To reiterate, no patient was included unless the cerebrospinal fluid culture yielded bacteria. A third possibility that could produce an underestimate of the disease is an overestimate of the Navajo population. The estimate of population used, based primarily on BIA data, was nearly 50 percent greater than the figure provided by the U.S. Census Bureau. In sum, the possibility that cases were underreported and the population was overestimated makes the high attack rates observed particularly impressive.

It does not seem likely, on the other hand, that the number of cases of meningitis was inflated by including other than Navajo patients. The surveyed hospitals, including the private ones, all subscribe to a uniform inpatient data system. In addition, the Public Health Service hospitals serve only Indians, except in emergencies, and tribal affiliation is recorded for each patient. Consequently, it was possible to exclude non-

Indians or persons of other tribes, such as Hopi or Zuni, who live in the same general area as the Navajo.

It is difficult to understand why meningococcal meningitis is not more frequent among the Navajo. Unusual crowding has been related to increases in meningococcal disease on several occasions (*12–14*). According to the BIA census data used in this study, the average number of persons per household for the Navajo varies from 5.31 to 5.95 in different sections of the reservation. The usual Navajo home is a one- or two-bedroom board house. Typically, two or more such structures are grouped with a traditional hogan, an eight-sided, single-room dwelling, in an isolated camp. Thus, the family's living quarters are often extremely crowded, but family groups are widely scattered. This low population density may inhibit the spread of meningococci, possibly balancing the effect of family crowding. Moreover, suboptimal socioeconomic conditions have not been found to be associated with meningococcal meningitis in recent studies of other populations (*6,7,9*).

The relatively high frequency of pneumococcal and *H. influenzae* found in this study is also difficult to explain. Possibly, however, since otitis media is extremely common in Navajo children (*15–17*) and since *D. pneumoniae* and *H. influenzae* are the major bacterial pathogens for middle-ear infection (*18*), meningitis sometimes is a complication of untreated or inadequately treated otitis media. The incidence of chronic suppurative otitis media, often resulting from inadequate treatment of acute otitis, has been reported to be more than 15 times more common among the Navajo than among Pittsburgh schoolchildren (*15*). It is now recognized that most of the *H. influenzae* strains isolated from middle-ear exudates are nonencapsulated (nontypable) and that less than 10 percent are type b, which have the potential for producing meningitis (*19*). The frequency of otitis media, however, is so high among the Navajo that *H. influenzae* type b meningitis in even a small proportion of children with *H. influenzae* type b middle-ear infection could account for a relatively large number of cases of meningitis.

It is also possible that the frequency of pneumococcal and *H. influenzae* meningitis (and possibly otitis media as well) is related to the difficult living conditions of the Navajo: harsh climate, limited access to water, high unemployment rate, and small, crowded homes with poor sanitation (*11*). Although the importance of socioeconomic factors in the pathogenesis of these infections has not been clearly elucidated, some studies have shown correlations between family income or educational level and frequency of bacterial meningitis, particularly that due to *H. influenzae* and *D. pneumoniae* (*7–9*).

The frequency of bacterial meningitis in Navajos during the first year of life may reflect a greater exposure of infants to these organisms in this culture than that of other groups in which the peak attack rates are spread over a longer age span (*3*). Relatively few cases, however, occurred during the first 3 months of life, a finding similar to observations in other studies (*3–9*). This relatively low frequency suggests that transplacental antibodies against *H. influenzae* type b were protective. A recent report of *H. influenzae* among very young infants in Florida (*20*) raises the question of whether maternal immunity to this organism has become less frequent than it was in earlier years (*21*). There is certainly no evidence, however, of waning maternal immunity from this study of the Navajo people, nor from analysis of recent cases of *H. influenzae* meningitis from the Pittsburgh area (*3*). Moreover, immunity to *H. influenzae* type b appears to develop quite early among Navajo children, as indicated by the small number of cases of *H. influenzae* after the second year of life.

A relatively large proportion of pneumococcal meningitis cases occurred during the first 3 months of life, 11 out of 55, but only 1 case was found during the first month. Indeed, there were only four other cases of bacterial meningitis in the neonatal period (first 28 days): two were caused by *E. coli,* one by beta-hemolytic streptococcus, and one by *Proteus.* The incidence of neonatal meningitis was, therefore, 0.29 per 1,000 live births, which compares favorably with estimates of 0.40 and 0.46 per 1,000 for other populations in this country (*22*). The explanation for the low frequency of neonatal meningitis among the Navajo may be inherent in the pathogenesis of this condition, which relates more to maternal infection, prematurity, and complications of pregnancy and delivery than to the general living conditions of the family. It is of interest in this regard that, although the Navajo infant mortality rate is high (31.5 per 1,000 live births), the neonatal mortality rate (14.9 per 1,000 live births) is similar to that for the United States as a whole (*11*), probably because nearly all Navajo infants are delivered in hospitals and because most maternal and infant care is provided by specialists. In contrast, the postneonatal mortality rate, which is more likely to be related to poor sanitation, inadequate nutrition, and limited use of health services, is very high among the Navajo (16.6 per 1,000 live births) in comparison with the rate for the general U.S. population (4.7 per 1,000 live births in 1973).

The case fatality rates among the Navajo observed in this study are not very different from those reported for other population groups. The rate for *H. influenzae* meningitis of 9.0 percent is close to the rate for the country as a whole (8.9 percent) (*10*), although somewhat higher than that for the Pittsburgh area (3.2 percent for the years 1961–71) (*3*). It should be stressed that more than three-fourths of the Navajo patients with *H. influenzae* meningitis were under 1 year of age, and that case fatality rates tend to be higher among infants than among older children. All of the Navajo deaths from *H. influenzae* occurred during the first year of life. It is likely that the outcome of bacterial

meningitis among the Navajo was as favorable as it was partly because the patients were treated in hospitals by highly motivated health personnel (*17*).

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SYNOPSIS

COULEHAN, JOHN L. (University of Pittsburgh School of Medicine), MICHAELS, RICHARD H., WILLIAMS, KARL E., LEMLEY, DIANA K., NORTH, CHARLES Q., Jr., WELTY, THOMAS K., and ROGERS, KENNETH D.: Bacterial meningitis in Navajo Indians, Public Health Reports, Vol. 91, September-October 1976, pp. 464–468.

An analysis of 219 confirmed cases of bacterial meningitis among Navajo Indians during a 5-year period, July 1, 1968, through June 30, 1973, revealed that 56 percent were caused by *Haemophilus influenzae,* 26 per-percent by *Neisseria meningitidis,* 6 percent by *Mycobacterium tuberculosis,* and 6 percent by other organisms. The annual incidence of *H. influenzae* meningitis (17.7 per 100,000 persons) and that of pneumococcal meningitis (8.0 per 100,000) were much higher than the rates for these diseases reported from other population groups. The annual incidence of meningococcal meningitis (2.0 per 100,000) was similar to that found elsewhere.

There was an unusual concentration of cases during the first year of life; 78 percent of *H. influenzae,* 64 percent of pneumococcal, and 50 percent of meningococcal meningitis occurred during this time. However, bacterial meningitis during the first month of life was not frequent (0.29 per 1,000 live births). Case fatality rates were similar to those reported for other population groups.