Trends in Diarrhea-associated Hospitalizations Among American Indian and Alaska Native Children, 1980–1995

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ABSTRACT. *Objective.* **To describe trends in diarrhea- associated hospitalizations among American Indian and Alaska Native (AI/AN) children and to estimate the morbidity from rotavirus.**

Design. **Retrospective analysis of Indian Health Service hospital discharge records.**

Patients. **AI/AN children 1 month through 4 years of age with a diarrhea-associated diagnosis listed on the hospital discharge record.**

Setting. **Hospitals on or near US Indian reservations from 1980 through 1995.**

Results. **During 1980 through 1995, 21 669 diarrhea-associated hospitalizations were reported among AI/AN children. The annual incidence of diarrhea-associated hospitalizations declined by 76% from 276 per 10 000 in 1980 to 65 per 10 000 in 1995. The median length of hospital stay decreased from 4 days during 1980–1982 to 2 days during 1993–1995. Diarrhea-associated hospitalizations peaked during the winter months (October through March), especially among children 4–35 months of age, with the peaks appearing first in the Southwest during October and moving to the East in March. In the early years of the study (1980–1982), the rate of diarrhea-associated hospitalizations among AI/AN children (236 per 10 000) was greater than the national rate (136 per 10 000). By the end of the study period (1993–1995), the rate for AI/AN children (71 per 10 000) was similar to the national rate (89 per 10 000), although the rate for AI/AN infants remained higher than the national rate for infants.**

Conclusions. **Diarrhea-associated hospitalization rates for AI/AN children have declined to a level similar to that of the national population. Rotavirus may be an important contributor to diarrheal morbidity among AI/AN children, underscoring the need for vaccines against this pathogen.** *Pediatrics* **1999;103(1). URL: http://www.pediatrics.org/cgi/content/full/103/1/e11; *Indian health, diarrhea, hospitalizations, epidemiology, children, rotavirus.***

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ABBREVIATIONS. NHDS, National Hospital Discharge Survey; AI/AN, American Indian and Alaska Native; IHS, Indian Health Service; ICD–9–CM, International Classification of Diseases, 9th revision, Clinical modification; NCHS, National Center for Health Statistics; CI, confidence interval; SE, standard error; ORT, oral rehydration therapy.

Diarrhea is among the leading causes of morbidity and mortality in children younger than 5 years of age in developing countries.[1,2] In the United States, diarrhea is not considered a major threat to child survival[3,4]; however, the morbidity and cost of the severe outcomes of this disease, particularly hospitalizations, are major public health concerns. Analyses based on National Hospital Discharge Survey (NHDS) data have indicated that in recent years, ~170 000 children younger than 5 years of age are hospitalized each year with diarrhea, and this number has not changed substantially during the last 2 decades.[5–7] Based on its unique epidemiologic characteristics (ie, predisposition for children 4–35 months of age, winter seasonality, and the geographic migration of winter rotavirus peaks from the Southwest to the Northeast United States),[8–11] rotavirus has been estimated to account for approximately one third of diarrhea-associated hospitalizations among US children. Hospitalizations are the most costly outcome of rotavirus diarrhea in the United States, and national hospitalization estimates have been used to establish the need for,[5–8] and cost-effectiveness of,[12] rotavirus vaccines. These vaccines are safe and effective,[13–16] and the first rotavirus vaccine was recently licensed for routine immunization of US infants.

Although NHDS data provide useful estimates of the health burden of diarrhea and of rotavirus among US children,[6,7] they exclude from the sampling frame certain groups of children for whom the epidemiologic characteristics of diarrhea might be sufficiently distinct from the general population to require special consideration in planning strategies for prevention and control. One such group is the ~1.3 million American Indians and Alaska Natives (AI/ANs) who receive medical care at Indian Health Service (IHS) hospitals.[17] AI/ANs living on or near Indian reservations suffer more from some aspects of poverty than most other minorities in the US, and it is generally accepted that their health status is below that of other Americans.[18,19] Epidemiologic studies have shown that AI/AN children have high rates of acute gastroenteritis that can be fatal and of severe

rotavirus diarrhea and are infected with rotavirus at an earlier age compared with other populations in the United States.[20–24] However, because these studies were conducted in the early 1980s among the White Mountain Apaches in Arizona, the findings are not timely nor representative of the entire AI/AN population, and do not allow policy-makers to assess the need for specific prevention strategies such as targeted immunization against rotavirus.

To provide timely, robust, and representative information on the health burden of diarrhea in the AI/AN population, we examined diarrhea-associated hospitalizations among children receiving IHS-reported medical care in the US from 1980 through 1995. Furthermore, we made comparisons with national estimates for US children to determine whether the epidemiologic characteristics of diarrhea-associated hospitalizations among AI/AN children are sufficiently distinct to require specific prevention strategies. Because specific data on rotavirus were unavailable, we used the epidemiologic characteristics of this pathogen to estimate its importance as a cause of diarrhea.

METHODS

Hospital discharges reported to the IHS for calendar years 1980 through 1995 were obtained from hospital discharge records for fiscal years 1980 through 1996.[25] The IHS data consist of patient discharge records obtained from IHS-operated, tribally operated, and community hospitals that have contract with IHS or tribes to provide health care services to eligible AI/ANs within the United States.[17] Of the 12 IHS Areas, 11 were included in this study; the California Area was not included because it does not have any IHS- or tribally-operated hospitals and did not report contract health services data to the IHS.[26] The Portland Area does not have IHS- or tribally-operated hospitals; therefore, not all hospitalizations may be reported, and the rates may be disproportionately low.[27]

The *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD–9–CM), was used to select hospitalizations of children 1 month through 4 years of age with diarrhea listed as one of the six diagnoses on the IHS record.[28] The ICD–9–CM codes used included diarrhea of determined etiology (bacterial, 001–005, 008.0–008.5, excluding 003.2; parasitic, 006–007, excluding 006.3–006.6; and viral 008.6–008.8), and diarrhea of undetermined etiology, including those presumed to be infectious (009.0–009.3) and noninfectious (558.9 and 787.91). Rotavirus, for which an ICD–9–CM code (008.61) was introduced in October 1992, was selected for hospitalizations only from the most recent 3 years (1993–1995). Infants younger than 1 month of age with diarrhea were not included because the ICD–9–CM code specifically classifies diarrhea as a neonatal illness identified with distinct codes.

Hospitalization data were examined for the 16-year study period, and trends for the most recent 3 years (1993–1995) were compared with those for the earliest 3 years (1980–1982). Annual hospitalization rates, expressed as the number of hospitalizations per 10 000 population of the corresponding age group, were calculated by age group (1–11 months and 1–4 years of age), sex, Area, period, and overall. Denominator data for IHS hospitalizations were determined by using the 1996 IHS user population estimates and adjusting for annual changes based on the IHS service population.[17] We examined trends in the children's hospitalizations during 1993–1995 by etiology and age group (1–3 months, 4–35 months, and 36–59 months). To examine seasonality of diarrhea-associated hospitalizations across the United States, IHS Areas were classified as follows: Northwest (Portland, Billings, and Alaska); Southwest (Phoenix, Navajo, Albuquerque, and Tucson); Northcentral (Bemidji and Aberdeen); Southcentral (Oklahoma); and East (Nashville).[17] Comparisons of hospital length of stay by time period and group were analyzed using the Wilcoxon rank-sum test.

Diarrhea-associated hospitalization rates for AI/AN children were compared with estimated national rates that were determined from a sample of short-stay, nonfederal general and children's hospitals by using NHDS data obtained from the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention.[29] National estimates of hospitalizations were weighted according to NCHS criteria and do not include hospitalizations at federal facilities, including IHS, military, and Public Health Service hospitals.[30] Diarrhea-associated hospitalizations were selected with a diarrhea-associated diagnosis listed as one of the seven diagnoses on the NHDS record.

NHDS national annual hospitalization rates (per 10 000 children) for the earliest and most recent 3-year periods for which IHS data were available (1980–1982 and 1993–1995, respectively) were calculated using the corresponding 1981 and 1994 census population estimates for children younger than 1 year, 1–4 years, and younger than 5 years of age.[31,32] The 95% confidence intervals (CIs) for the estimates of the NHDS hospitalization rates were calculated using standard error (SE) values for the rates. The SE values for the rates were calculated for both the 1993–1995 and the 1980–1982 time periods. For 1993–1995, SUDAAN, a computer program that takes into account complex survey design, was used to estimate the SE values for the estimates of the number of hospitalizations to calculate the relative SE values.[29,33] For 1980–1982, the relative SE values were estimated using linear interpolation of the largest approximate annual relative SE values of the estimated number of hospitalizations provided by NCHS.[29] The census denominator data were not subject to sampling error.[29]

RESULTS

During the 16-year study period, 21 669 diarrhea-associated hospitalizations were reported among AI/AN children 1 month through 4 years of age, accounting for 14% of total hospitalizations in this age group. The percentage of total childhood hospitalizations associated with diarrhea declined from 18% during 1980–1982 to 11% during 1993–1995. The majority (65.6%) of diarrhea-associated hospitalizations were reported among infants 1–11 months of age; however, the proportion of hospitalizations for this age group declined from 71% during 1980–1982 to 56% during 1993–1995 (Fig 1).

During 1993 through 1995, diarrhea was listed as the primary diagnosis for 64% (n = 13 847) of all diarrhea-associated hospitalizations. For 77% of hospitalizations, the cause of diarrhea was not specified (Table 1). Of the remaining, viruses accounted for 12%, along with bacteria (12%) and parasites (1%). Compared with 1980–1982, the proportion of diar-

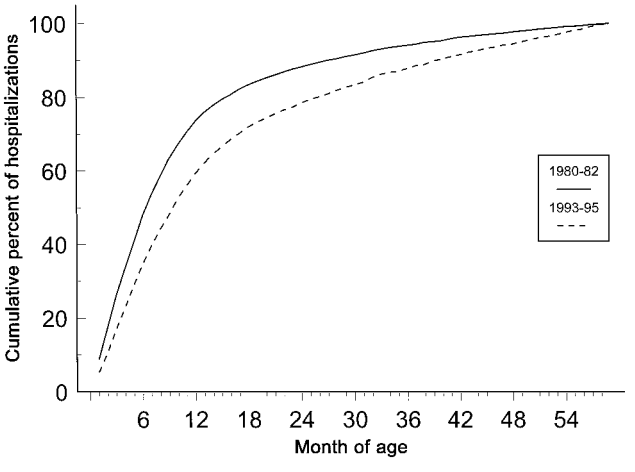


Fig 1. Cumulative percentage of diarrhea-associated hospitalizations by month of age for 1993–1995 and 1980–1982 among children 1 through 59 months of age, IHS.

TABLE 1. Diarrhea-associated IHS Hospitalizations Among Children 1–59 Months by Diagnostic Category, 1980–1995

Diagnostic Category*	ICD–9–CM Codes	Total 1980–1995		Annual Average 1980–1982		Annual Average 1993–1995		1993–1995/ 1980–1982† Change (%)
		No.	(%)	No.	(%)	No.	(%)	
Etiology Unspecified								
Presumed infectious	009–009.3	3109	(14)	388	(19)	49	(6)	−72
Presumed noninfectious	558.9, 787.91	13 641	(63)	1211	(60)	649	(73)	21
Etiology Specified								
Viral	008.6, 008.8	2489	(12)	187	(9)	109	(12)	33
Bacterial‡	001–005.9, 008–008.5	2537	(12)	225	(11)	86	(10)	−13
Parasitic‖	006–007.9	307	(1)	30	(2)	5	(1)	−60
Total		21 669	(100)	2006	(100)	884	(100)	—

* More than one diagnostic category (ICD–9–CM code) may be listed on each discharge record.
† Percentage change in proportion for 1993–1995 compared with that for 1980–1982.
‡ Excludes localized *Salmonella* infections (003.2).
‖ Excludes amebic liver abscess (006.3), amebic lung abscess (006.4), amebic brain abscess (006.5), and amebic skin ulceration (006.6).

rhea-associated hospitalizations of viral and presumed noninfectious etiology increased by 33% and 21%, respectively, whereas hospitalizations of presumed infectious, bacterial, and parasitic etiology declined 72%, 13%, and 60%, respectively. During the 3-year period (1993–1995) for which rotavirus-specific information was available, the pathogen was listed on 3% of all diarrhea-associated hospitalizations.

Overall, the median duration of a diarrhea-associated hospitalization was 3 days. The median duration of a diarrhea-associated hospitalization declined from 4 days in 1980–1982 to 2 days in 1993–1995 ($P < .0001$). The median length of stay for hospitalizations associated with rotavirus diarrhea was longer than that for diarrhea of other causes (3 days versus 2 days, respectively; $P < .001$). Overall, 21 deaths were reported among AI/AN children who were hospitalized with diarrhea. Nine deaths were reported among children hospitalized with diarrhea during 1980–1982, compared with one death during 1993–1995.

The annual rate of diarrhea-associated hospitalizations in children 1 month through 4 years of age declined by 76% from 276 per 10 000 in 1980 to 65 per 10 000 in 1995; during this period, the rate for infants 1–11 months of age declined by 83% from 1340 per 10 000 to 230 per 10 000, whereas the rate for children 12–59 months of age declined by 61% from 95 per 10 000 to 37 per 10 000 (Fig 2). Examination of diarrhea-associated hospitalizations by month of admission for the 16-year study period provided two important insights (Fig 3). First, winter peaks previously associated with rotavirus occurred each year and were most prominent among children 4–35 months of age. Second, although distinct winter peaks in diarrhea-associated hospitalizations also were seen among infants 1–3 months of age during the first 11 years of the study period (1980 through 1990), these peaks have become smaller in recent years.

To examine further the etiologic importance of rotavirus in children 1–35 months of age and in children 1–11 months of age, we examined geographic trends in peak hospitalizations during 1993–1995 by region to detect patterns determined previously to be characteristic for this pathogen. Composite data showed a pattern in winter hospitalizations, which peaked earliest in the Southwest region during October through December. The hospitalizations in the Navajo Area peaked in October, and those in the Phoenix and Albuquerque Areas peaked in December. The Northwest and the North-central regions demonstrated a peak in January, whereas the Southcentral and East regions had a peak in February and March.

We examined the composite monthly number of diarrhea-associated hospitalizations during 1993–

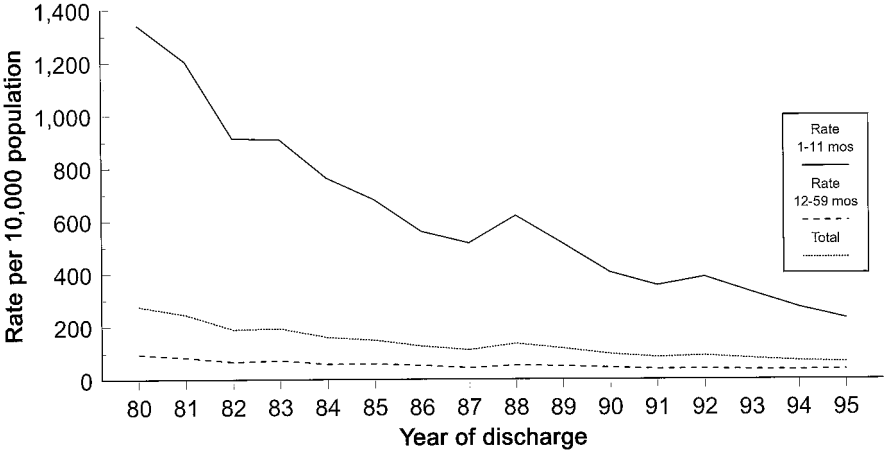


Fig 2. Diarrhea-associated hospitalization rate by year and age group among children 1 through 59 months of age, 1980 through 1995, IHS.

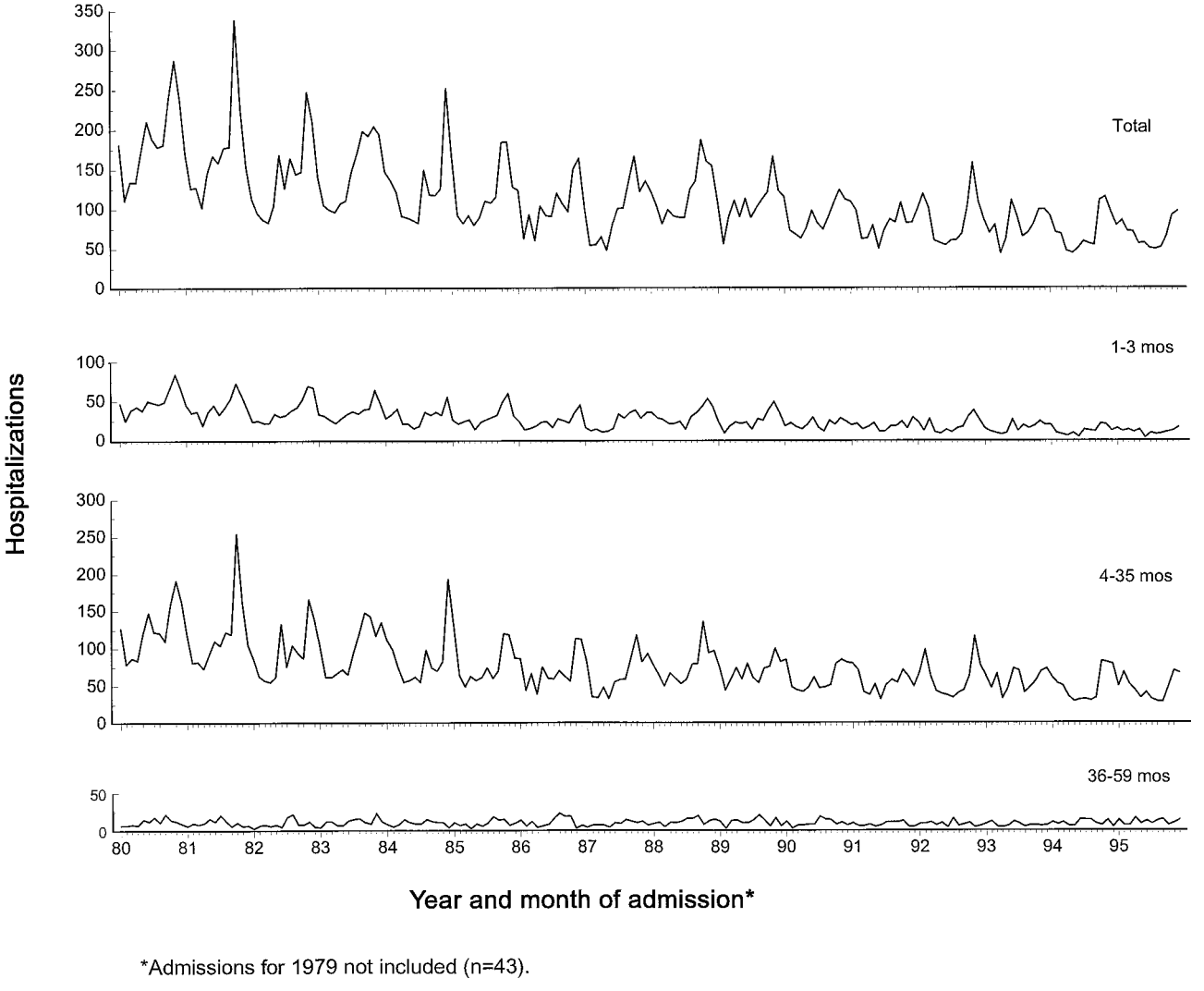
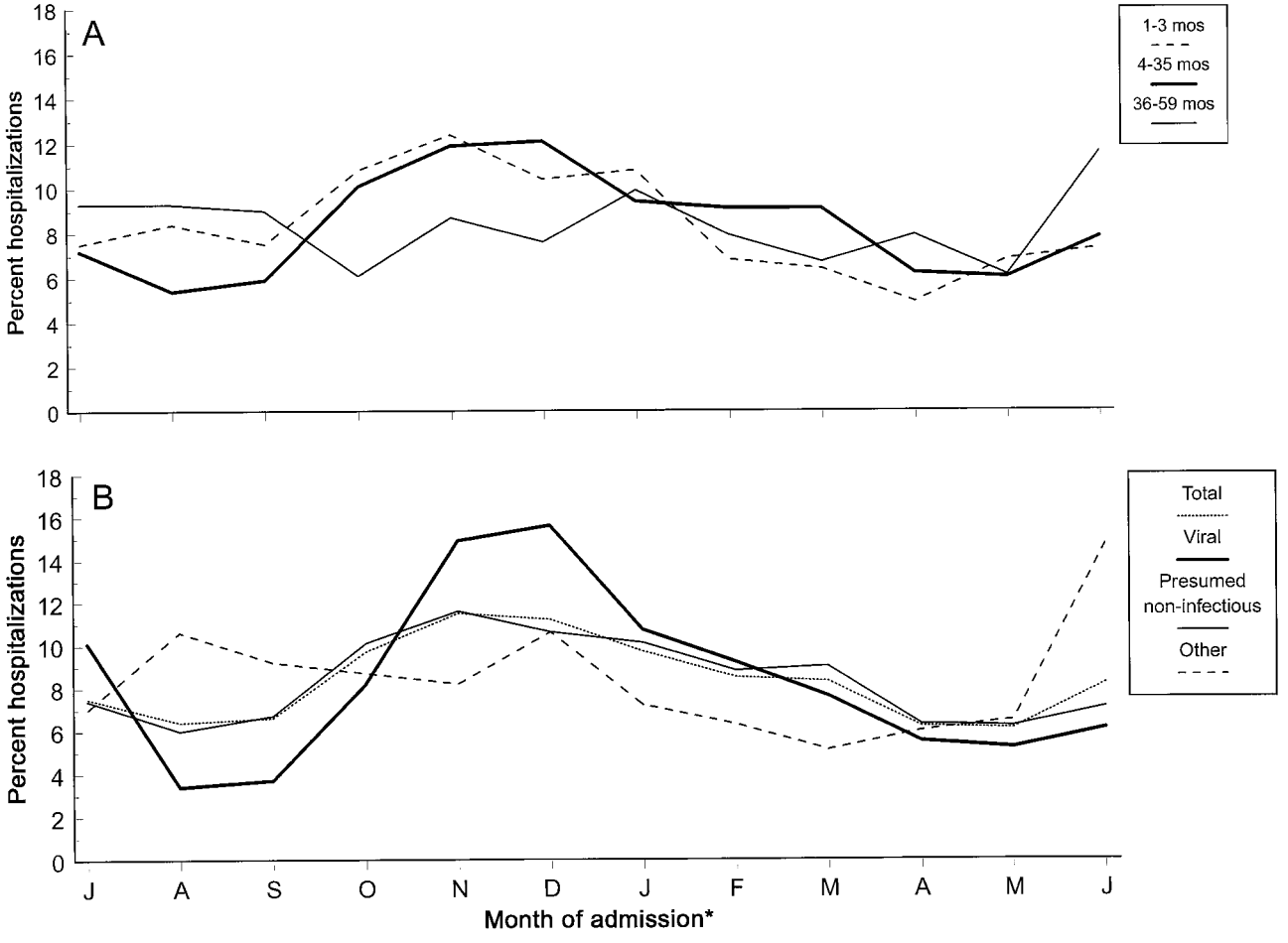


Fig 3. Monthly diarrhea-associated hospitalizations by age group among children 1 through 59 months of age, 1980 through 1995, IHS.

1995 by age group and etiology to determine seasonal and age-related trends (Fig 4). A winter seasonal peak in diarrhea-associated hospitalizations was observed among children aged 1–35 months; this peak was not observed in children 36–59 months of age (Fig 4, A). By etiology, the seasonal trends of diarrhea-associated hospitalizations reflected those of presumed noninfectious and viral etiology (that together accounted for 75% of all diarrhea-associated hospitalizations), whereas the remaining small fraction (13%) of hospitalizations specified as bacterial or parasitic etiology peaked during the summer months (Fig 4, B).

We examined rates of diarrhea-associated hospitalizations by Area to determine whether there were significant differences among the groups (Table 2). Overall, diarrhea-associated hospitalization rates were greatest among AI/AN children living in the Phoenix and Aberdeen Areas (285 per 10 000 and 226 per 10 000, respectively), whereas they were the lowest in the Portland and Oklahoma Areas (41 per 10 000 and 44 per 10 000, respectively). The rates of diarrhea-associated hospitalizations decreased between 40% and 93% in all Areas during 1993–1995 compared with 1980–1982, the greatest percentage declines were observed in Portland and Tucson (93% and 89%, respectively), and the greatest absolute declines over time were observed in Tucson and Phoenix (489 per 10 000 and 413 per 10 000, respectively).

To determine whether the morbidity associated with diarrhea among AI/AN children is greater than that among other children in the United States, we compared rates of diarrhea-associated hospitalizations derived from IHS and NHDS data for 1980 through 1982 and for 1993 through 1995 (Table 3). During 1980 through 1982, the rate of diarrhea-associated hospitalizations among AI/AN children 1 month through 4 years of age (236 per 10 000) was 74% greater than the NHDS-based national rate (136 per 10 000). The difference in diarrhea-associated hospitalization rates was particularly great among infants 1–11 months of age; for these children, the AI/AN rate was 230% greater than the national rate. There was no difference in diarrhea-associated hospitalization rates between AI/AN and national children 1–4 years of age. On the other hand, during 1993 through 1995, the rate of diarrhea-associated hospitalizations among AI/AN children 1 month through 4 years of age (71 per 10 000) was similar to the national rate (89 per 10 000); however, the rate



* Month of admission for discharges from 1993 through 1995.

Fig 4. Composite monthly diarrhea-associated hospitalizations by age group (A) and etiology among children 1 through 59 months of age (B), 1993 through 1995, IHS.

TABLE 2. Diarrhea-associated IHS Hospitalizations and Rates Among Children 1–59 Months by Area, 1980–1995

Area	1980–1995 Average Annual Population*	1980–1995		1980–1982		1993–1995		1993–1995/ 1980–1982 Rate Change (%)
		No.	Rate†	No.	Rate†	No.	Rate†	
Aberdeen	10 514	3808	226	1113	406	327	88	−78
Alaska	9973	814	51	190	77	163	46	−40
Albuquerque	6531	1176	113	297	186	173	73	−61
Bemidgi	5263	423	50	156	125	30	15	−88
Billings	5456	1233	141	406	296	110	58	−80
Nashville	2150	546	159	156	388	114	122	−69
Navajo	22 490	5582	155	1383	236	881	114	−52
Oklahoma	22 761	1619	44	381	72	194	24	−67
Phoenix	11 699	5337	285	1501	555	596	142	−74
Portland	6290	411	41	143	110	18	8	−93
Tucson	2131	720	211	291	551	46	62	−89
Total	105 258	21 669	129	6017	236	2652	71	−70

* Population based on children <5 years of age.
† Rates are expressed per 10 000 persons.

for infants 1–11 months of age was 45% greater than the national rate (275 per 10 000 compared with 192 per 10 000, respectively), whereas that for children 12–59 months of age was 42% lower than the national rate (36 per 10 000 compared with 64 per 10 000, respectively).

DISCUSSION

In this analysis, we observed a continuous decline over the 16-year study period in diarrhea-associated hospitalization rates in AI/AN children 1 month through 4 years of age receiving medical care in IHS hospitals throughout the United States. Overall, the

TABLE 3. Diarrhea-associated IHS and National Hospitalizations and Rates* Among Children 1–59 Months for 1980–1982 and 1993–1995

	1980–1982						1993–1995					
	IHS		NHDS			IHS/NHDS Rate Difference (%)	IHS		NHDS			IHS/NHDS Rate Difference (%)
	No.	Rate	No.	Rate	(95% CI)		No.	Rate	No.	Rate	(95% CI)	
Age												
1–11 m	4244	1148	378 115	348	(300,396)	230	1486	275	222 727	192	(148,235)	43
1–4 y	1773	81	310 315	78	(68,88)	4	1166	36	303 336	64	(53,75)	−44
Sex												
Male	3283	253	385 790	149	(124,159)	70	1501	79	294 920	97	(80,115)	−19
Female	2734	218	302 640	122	(105,139)	79	1151	62	231 143	80	(63,97)	−21
Total	6017	236	688 430	136	(118,153)	74	2652	71	526 063	89	(64,114)	−20

* Rates are expressed per 10 000 persons, using population based on children <5 years of age.

annual rate of diarrhea-associated hospitalizations declined by 76% from 276 per 10 000 in 1980 to 65 per 10 000 in 1995. The decline in diarrhea-associated hospitalization rates occurred among both infants 1–11 months and children 12–59 months of age, although the absolute decline in rate was greater for the former group. Furthermore, the percentage of all childhood hospitalizations attributable to diarrhea declined from 18% during 1980–1982 to 11% during 1993–1995, and the median duration of diarrhea-associated hospitalizations declined from 4 days during 1980–1982 to 2 days in 1993–1995. Together with the decline in diarrhea-associated hospitalization rates, these trends reflect a reduction in the health burden of this disease in AI/AN children. Although diarrhea-associated morbidity declined in all IHS Areas, representing an important public health accomplishment, children in certain Areas (eg, Phoenix, Navajo) continue to have high hospitalization rates for diarrhea, indicating that this disease remains an important and preventable cause of morbidity in AI/AN children.

The large reduction in diarrhea-associated hospitalization rates for AI/AN children during 1980–1995 contrasts with the relatively smaller decline seen in rates for the national population of children during the same period. It can be hypothesized that a substantial proportion of the decline in diarrhea-associated hospitalization rates for AI/AN children might be artificial and reflect the migration of patients out of the IHS system to seek alternative sources of health care, especially given the increased access of these children to Medicaid. Several lines of evidence argue against this hypothesis. First, most Indian health facilities are located in rural regions, and their user population primarily represents most of the AI/AN population that lives in geographic areas on or near reservations, which have few other options for health care.[27,34] Second, the IHS is unique among US private and public health programs in that free comprehensive medical care is provided to the AI/AN population regardless of ability to pay, thereby providing a financial incentive for AI/ANs to seek medical care primarily in IHS facilities.[35] Third, although it is recognized that a fraction of AI/ANs receive health care outside the IHS, services received through alternate providers appear to supplement, and not replace, those services in IHS facilities.[35] Fourth, because rates of hospitalization were calculated with the IHS user population as the denominator, they should not be biased by migration of patients out of the IHS system.

The decline in diarrhea-associated hospitalization rates among AI/AN children could be attributed to several factors. After the implementation of the 1976 Indian Health Care Improvement Act, which was intended to elevate the health status of AI/ANs to a level similar to that of the general population, increased resources were used to expand health services, provide safe drinking water, and construct sanitary disposal facilities.[17,27,36] In the early 1980s, numerous studies demonstrated the effectiveness of oral rehydration therapy (ORT) in the management of infantile diarrhea in US children,[37,38] and the American Academy of Pediatrics began recommending the use of ORT in 1985.[39] The White Mountain Apache region was one of the first sites where ORT was promoted in the United States, and the aggressive implementation of this intervention could account for part of the decline in diarrhea-associated hospitalization rates in this and other regions of the IHS. Increased coverage with measles vaccination might have prevented severe measles-associated diarrhea.[40,41] Finally, a general improvement in the health status of the AI/AN population, which is reflected in the decline in infant mortality and an increase in life expectancy over the past 2 decades,[27] may have contributed to the decline in diarrhea-associated hospitalization rates.

A goal of this study was to estimate the etiologic importance of rotavirus in AI/AN children hospitalized with diarrhea and to determine whether the epidemiologic characteristics of rotavirus diarrhea were sufficiently distinct from those for the national population to require targeted or selective immunization against this pathogen. Only ~3% of diarrhea-associated hospitalizations among AI/AN children were coded with a rotavirus diagnosis during 1993–1995; this proportion underestimates the true disease burden of rotavirus because testing for this pathogen may be discouraged by pediatricians because it adds cost but does not alter treatment.[42] Several epidemiologic characteristics of diarrhea-associated hospitalizations among AI/AN children suggest that rotavirus may be a major contributor to diarrheal morbidity. Each year, the number of diarrhea-associated hospitalizations peaked during the winter months, especially among children 4 through 35

months of age—the season and age range when a child is at greatest risk for rotavirus infection.[8–11] Furthermore, examination of geographic trends of peak diarrhea-associated hospitalizations showed that the number of hospitalizations peaked earliest in the Southwest during October through December and peaked during February and March in the Southcentral and East regions, which is consistent with the pattern reported previously for rotavirus diarrhea.[11,43] Although our findings underscore the potential etiologic importance of rotavirus in AI/AN children hospitalized with diarrhea, the decline in hospitalization rates during 1980–1995 to a level similar to that of the national population indicates that AI/AN children are not at a sufficiently greater risk of severe rotavirus diarrhea to require selective or targeted immunization against this pathogen. However, because AI/AN children have a high rate of diarrhea-associated hospitalization in their first year of life, coverage of these infants will be important if the vaccine is to have the desired impact.

This is the first study of the epidemiology of diarrhea-associated IHS hospitalizations. The disease burden of diarrhea in AI/AN children, as reflected by the number of diarrhea-associated hospitalizations and the median length of hospital stay, has declined over time to a level similar to that of the rest of the national population. However, the high hospitalization rates for some IHS Areas and for infants indicate that diarrhea still is an important disease to address and monitor. The epidemiologic analysis in this study also suggests that rotavirus may be an important contributor to diarrhea-associated morbidity, indicating the importance of vaccines against rotavirus in AI/AN children. The IHS data, which provide timely and representative information on the health burden and trends of diarrhea-associated hospitalizations of AI/AN children residing in the IHS Areas, should provide a useful tool to monitor the impact of rotavirus vaccines. However, the incompleteness of detection of, and the lack of laboratory-confirmed information on, rotavirus cases are important limitations of these data. A network of sentinel IHS hospitals that report complete information on laboratory-confirmed cases of rotavirus diarrhea could provide more accurate information to assess the disease burden of this pathogen and monitor the impact of vaccines.

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