Hepatitis A Incidence and Hepatitis A Vaccination Among American Indians and Alaska Natives, 1990–2001

Stephanie R. Bialek, MD, MPH, Douglas A. Thoroughman, PhD, Diana Hu, MD, Edgar P. Simard, BS, Jody Chattin, MPH, Jim Cheek, MD, MPH, and Beth P. Bell, MD, MPH

Objectives. We assessed the effect on trends in hepatitis A incidence of the 1996 recommendation for routine hepatitis A vaccination of American Indian/Alaska Native (AIAN) children.

Methods. We examined trends in hepatitis A incidence among AIAN peoples during 1990–2001 and vaccination coverage levels among children on the largest American Indian reservation.

Results. Hepatitis A rates among AIANs declined 20-fold during 1997–2001. Declines in hepatitis A incidence occurred among AIANs in reservation and metropolitan areas. Among 1956 children living on the Navajo Nation whose medical records were reviewed, 1508 (77.1%) had received at least one dose of hepatitis A vaccine, and 1020 (52.1%) had completed the vaccine series.

Conclusions. Hepatitis A rates among AIAN peoples have declined dramatically coincident with implementation of routine hepatitis A vaccination of AIAN children. (*Am J Public Health.* 2004;94:996–1001)

Historically, hepatitis A incidence has been substantially higher among American Indians and Alaska Natives (AIANs) than in other racial/ethnic groups in the United States.[1] In the 1980s, the lifetime risk of hepatitis A virus (HAV) infection among AIANs living on reservations and in Alaskan villages approached 90%.[2,3] Reported cases of hepatitis A among AIAN peoples during 1990–1995 accounted for 5.0%–8.7% of all US cases, although AIANs constituted only 0.86% of the total US population. The high rates of hepatitis A among AIAN peoples were largely the result of periodic, communitywide epidemics on reservations and in rural Alaskan communities. During a 1992–1993 outbreak in 25 rural Alaskan villages, the peak reported incidence of hepatitis A exceeded 2000 cases per 100 000 inhabitants in a 12-month period.[4] Similar rates have been documented during epidemics among AI populations living on reservations.[2] Although the epidemiology of hepatitis A among AIANs living in urban areas has not been as well characterized, disease rates consistently have been severalfold higher than rates among persons of other races/ethnicities living in the same areas.[5]

Hepatitis A vaccine was licensed in the United States in 1995 and was first provided to AIAN children in a pilot program implemented by the Indian Health Service (IHS) on several Northern Plains Indian reservations during 1995–1996.[6] In December 1996, the Advisory Committee on Immunization Practices (ACIP) recommended routine vaccination of children in populations with high rates of hepatitis A, including AIAN children.[7] The vaccine became available free of charge to IHS healthcare facilities, after publication of the ACIP recommendations and the parallel Vaccines for Children (VFC) resolution, through VFC funding to state health departments. To assess the effect of the ACIP recommendation on hepatitis A incidence among AIAN peoples, we analyzed national surveillance data to characterize trends in disease incidence in counties with large AIAN populations before and after the implementation of routine hepatitis A vaccination of AIAN children, and we assessed vaccination coverage among children living on the largest American Indian reservation.

METHODS

Hepatitis A Vaccination

For this study, the period 1990–1996 was defined as the period before implementation of routine hepatitis A vaccination for AIAN children, and 1997–2001 was defined as the period during which routine vaccination was implemented.

Hepatitis A Surveillance

All states require hepatitis A cases to be reported to public health authorities, which in turn report cases to the Centers for Disease Control and Prevention's National Notifiable Diseases Surveillance System (NNDSS).[8] The case definition requires the presence of jaundice or elevated aminotransferase levels and either serological confirmation (positive for immunoglobulin M antibody to hepatitis A virus) or an epidemiological link to a serologically confirmed case.[9] During 1966–1989, cases were aggregated by county, age, and sex and were reported weekly to the Centers for Disease Control and Prevention. Beginning in 1990, demographic data that included race/ethnicity, categorized as White, Black, AIAN, or Asian/Pacific Islander, were reported to NNDSS through the National Electronic Telecommunications System for Surveillance.

To analyze hepatitis A incidence among AIAN peoples in urban areas, we identified the 30 counties with AIAN populations greater than 10 000 in 1999, based on population estimates compiled by the US Census Bureau.[10] We identified a subset of those counties that contained large urban areas and for which race/ethnicity was recorded for at least 70% of hepatitis A cases reported to NNDSS during 1990–2000. Nine urban counties met these criteria and were included in the analysis (2 counties each in Oklahoma and Texas; 1 county each in Alaska, Illinois, Minnesota, Nevada, and Washington).

To analyze hepatitis A incidence in rural reservation communities, we initially selected the 17 counties that included the 10 most populous reservations (8 counties in Arizona;

3 each in New Mexico and South Dakota; 2 in Montana; 1 in Utah). Of these 17 counties, 3 counties in Arizona were excluded: 2 that included large metropolitan areas and 1 in which race/ethnicity was reported for less than 70% of hepatitis A cases. The remaining 14 reservation counties were included in the analysis. Because information on race/ethnicity was not available in NNDSS data before 1990, we calculated overall hepatitis A incidence during 1970–2001 for these 14 reservation counties to provide an estimate of long-term hepatitis A incidence trends in reservation communities.

Hepatitis A Incidence Trends

Overall age- and race/ethnicity-specific hepatitis A incidence rates were calculated for the United States and the selected urban and rural reservation areas during 1990–2001 with 1990 and 2000 population denominators and midyear intercensal population estimates.[11–15] Rates of hepatitis A in rural reservation counties before 1990 were calculated with 1970 and 1980 population denominators and midyear intercensal population estimates.[16,17] Race/ethnicity-specific hepatitis A rates were calculated for AIANs and for persons of all other racial groups combined (non-AIANs). Race/ethnicity-specific incidence in rural reservation areas could not be calculated for 1993 because case reports from Arizona did not include race/ethnicity.

Hepatitis A Vaccination Coverage Survey

The Navajo Area IHS system initially began offering hepatitis A vaccine in 1996 for the cohort of children who were aged 2–12 years, and it currently provides the vaccine to children aged 2–18 years. A hepatitis A vaccination coverage survey among children aged 3–6 years living in the Navajo Nation who received medical care from the Navajo Area IHS system was undertaken during June–September 2000. A systematic random sample was selected from a list of the children born between March 1, 1993, and February 28, 1997, who had ever received services at a Navajo Area IHS facility. Current residence on the Navajo Nation was determined by local public health nurse verification or by an IHS clinic visit during the year before the survey (July 1, 1999, to June 30, 2000). Data were abstracted from the medical chart, computerized health record, and public health nursing vaccination record of each child with a standard survey form. During the period of time covered by the survey, both 2-dose and 3-dose schedules had been used to vaccinate children.[6] Completion of the vaccine series was defined as receipt of the first dose on or after age 24 months, with either at least a 5-month interval between the first and second dose or, for the 3-dose series, an interval of at least 1 month between the first and second dose and at least 5 months between the second and third doses.

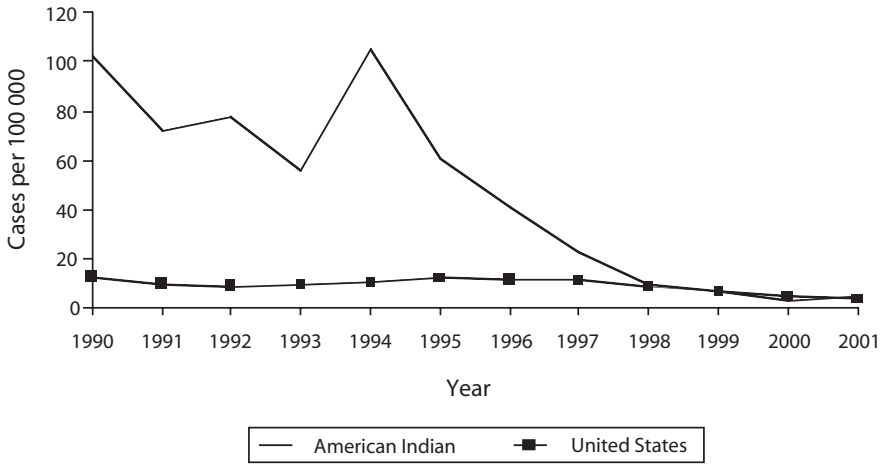

FIGURE 1—Hepatitis A incidence: American Indians/Alaska Natives and the general United States population, 1990–2001.

RESULTS

Incidence Nationwide

During 1990–1996, annual hepatitis A incidence among AIAN peoples nationwide ranged from 41.0 to 104.9 cases per 100 000 population—rates 3.5 to 10.2 times higher than the overall US rate of 9.1–12.7 per 100 000 (Figure 1). Incidence was highest among AIAN children, ranging from 187.2 per 100 000 in 1990 to 47.4 per 100 000 in 1996 among children aged less than 5 years and 299.4 per 100 000 in 1990 to 77.9 per 100 000 in 1996 among children aged 5–14 years (Figure 2). During 1997–2001, hepatitis A rates among AIAN peoples nationwide declined 20-fold to 5.2 per 100 000 in 2001, compared with the 3-fold decline in the overall US rate to 3.9 per 100 000. This decline during 1997–2001 occurred among all age groups of AIANs but was particularly marked among children. Incidence among AIAN peoples in 2001 was 1.9 per 100 000 among those aged less than 5 years and 1.0 per 100 000 among those aged from 5 to 14 years.

Incidence in Urban Counties

The AIAN populations of the 9 urban counties selected for analysis ranged from 7147 to 25 993 in 1990 and represented 0.24%–6.6% of the overall county populations. During 1990–1996, the annual hepatitis A incidence among AIAN peoples living in these urban counties ranged from 15.5 to 101.7 per 100 000, 1.6 to 11.8 times higher than the non-AIAN disease rates of 8.6–17.4 per 100 000 in these same counties (Figure 3a). Incidence was highest among AIANs aged 5–14 years during 1990–1996, with a peak rate of 219.1 per 100 000 reported in 1992 (Figure 3b). Hepatitis A incidence among AIAN peoples in urban areas declined after 1996 to 2.0 per 100 000 in 2001, lower than the non-AIAN rate of 2.8 per 100 000. Incidence among AIAN peoples declined in all age groups, with no cases reported among AIANs aged less than 5 years or aged 5–14 years during 2000–2001.

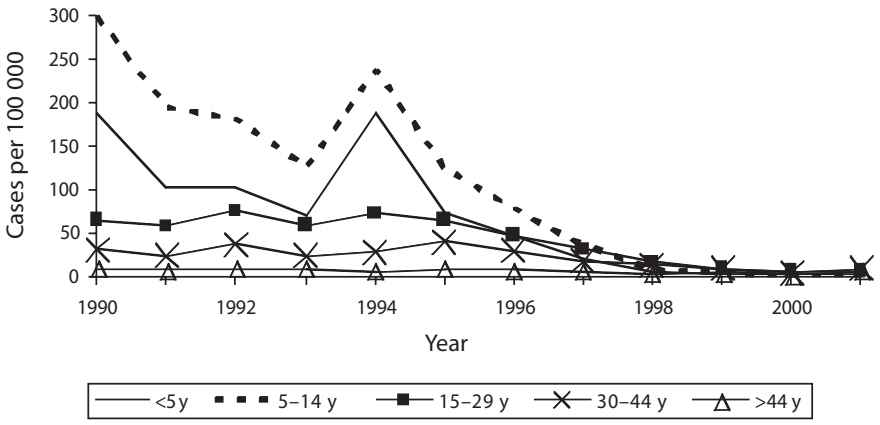

FIGURE 2—Hepatitis A incidence among American Indians/Alaska Natives, by age group: 1990–2001.

Incidence in Rural Reservation Counties

In 1990, the AIAN populations of the 14 rural reservation counties represented 10.7%–94.2% of the overall county populations. The combined AIAN populations of these counties represented 58.0% of all AIANs living on reservations with populations of 5000 or more. During 1990–1996, hepatitis A incidence during epidemic and interepidemic periods was substantially higher among AIAN peoples compared with non-AIANs living in these reservation areas (Figure 4a). Incidence rates among AIAN peoples ranged from 75.4 to 547.1 per 100 000 and were 4.7 to 30.4 times higher than the rates of from 6.0 to 66.3 per 100 000 observed among non-AIANs. During this period, incidence was highest among AIAN children, with a peak rate of 1400.2 per 100 000 reported in 1990 among children aged 5–14 years (Figure 4b). During 1997–2001, hepatitis A incidence declined 26-fold among AIAN peoples living in reservation counties, from 26.5 per 100 000 in 1997 to 0.0 per 100 000 in 2001, compared with 4.7 per 100 000 among non-AIANs. Rates among AIAN children aged less than 5 years living in reservation counties decreased during 1997–2001 from 15.1 per 100 000 to 0.0 per 100 000 during 1999–2001 and among children aged 5–14 years from 48.5 per 100 000 to 0.0 per 100 000 during 2000–2001. In 2001, the overall rate in these counties of 2.9 per 100 000 was the lowest rate reported since 1973 (0.9 per 100 000).

Navajo Nation Hepatitis A Incidence and Vaccination Coverage

In the 2 counties that encompass a majority of the Navajo Nation (Apache and Navajo Counties, AZ), communitywide hepatitis A outbreaks occurred every 4–7 years, with a peak rate among AIANs of 717.7 per 100 000 during the most recent outbreak in 1994. Overall disease incidence in these 2 counties during the interepidemic period 1985–1989 ranged from 25.3 to 69.8 per 100 000. On the basis of the observed epidemic cycle, the next communitywide outbreak would have been expected to have occurred by 1999. However, disease incidence among AIANs in these counties remained low, with rates of 8.7 per 100 000 and 14.4 per 100 000 during 1997–1998 and 0.0–1.0 per 100 000 during 1999–2001. The overall disease rate of 1.8 per 100 000 in 2000 was the lowest ever reported in the 2 counties.

Of the 23 590 children aged 3 to 6 years, born during 1993–1997, who had ever received services at a Navajo Area IHS facility, 1967 were selected for the hepatitis A vaccination coverage survey and 1956 were included in the analysis. Four hundred thirty-four (22.2%) of the records initially selected were replaced (273 because the children had moved, 161 because the medical chart was unavailable for review). Eleven duplicate records were removed. Overall, 1508 (77.1%) children aged 3–6 years living on the Navajo Nation in June 2000 had received at least 1 dose of hepatitis A vaccine, and 1020 (52.1%) had completed the hepatitis A vaccination series. The proportion of children who received the first dose by 27 months of age was lowest among children 6 years of age (1.6%) and highest among children 3 years of age (44.9%).

DISCUSSION

In 1996, routine hepatitis A vaccination was recommended for preschool AIAN children, with catch-up vaccination recommended for older children up to 10–12 years of age.[6] National surveillance data demonstrate a dramatic decrease in hepatitis A incidence among AIAN peoples coincident with implementation of these recommendations. In 2001, hepatitis A incidence among AIAN peoples was over 20 times lower than at the beginning of the decade. Provisional data indicate that this decline in incidence was sustained through 2002. The decline in hepatitis A rates, seen in urban and reservation populations in all age groups, was greatest among children. A decline of this magnitude and apparent durability has not been observed in the previous 30 years of national hepatitis surveillance.[18]

The vaccine coverage survey documented that most preschool-aged AIAN children living on the Navajo Nation, the largest reservation in the United States, have received at least 1 dose of hepatitis A vaccine. In Alaska, first-dose hepatitis A vaccine coverage levels among Alaska Native children aged 24–35 months in 2000 ranged from 42% to 71% by census area (R. Singleton, written personal communication). In addition, a 1999 survey of IHS vaccination providers nationwide indicated that 93.7% of facilities offered hepatitis A vaccine to preschool- and 63.6% to school-age children.[19] Although coverage among all AIAN children may be lower than indicated by these clinic-based analyses, taken together, these data indicate that a substantial proportion of AIAN preschool children have received at least 1 dose of hepatitis A vaccine. Vaccina-

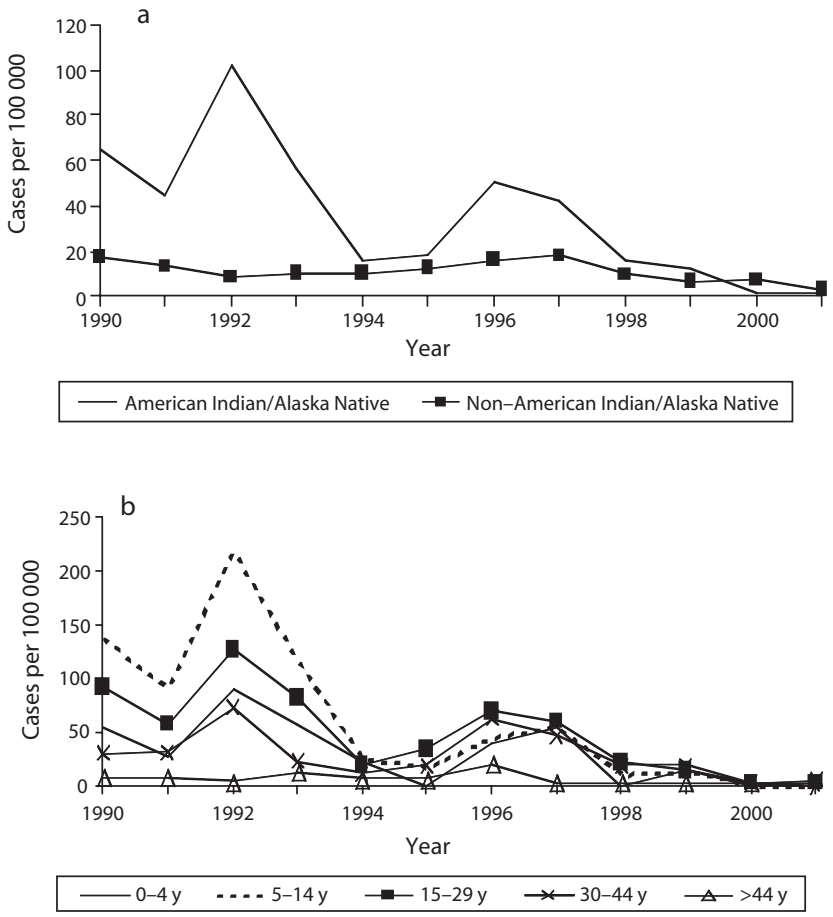

FIGURE 3—Hepatitis A incidence in 9 urban counties, (a) among American Indians and non–American Indians and (b) among American Indians/Alaska Natives, by age group: 1990–2001.

tion coverage among school-aged children is less well characterized but is likely to be lower.

Before the introduction of vaccination, hepatitis A was highly endemic in AIAN communities. Large communitywide epidemics occurred regularly and continued until the pool of susceptible individuals was essentially exhausted.[2] After several years of low disease rates, an outbreak would recur when a sufficient number of susceptible persons had accumulated. Because of this pattern, essentially all adults were immune to HAV infection, and transmission was sustained primarily among susceptible children.[2,3,20]

The results of our analysis indicate that the level of immunity achieved among children through vaccination has been adequate to substantially reduce HAV transmission in AIAN communities and to affect the pattern of periodic communitywide outbreaks. These findings are consistent with a previous study that indicated that 1-dose hepatitis A vaccination coverage levels of approximately 80% interrupted HAV transmission during a communitywide outbreak in rural Alaska Native villages.[4] However, the level of vaccination coverage needed to sustain a reduction in hepatitis A incidence, or to eliminate HAV transmission and prevent epidemics rather than simply delay them, is unknown. It is likely that sustained vaccination of young children will be necessary to maintain high levels of population immunity and the low disease rates currently observed in AIAN communities.

Our analysis demonstrated a smaller reduction in hepatitis A incidence among AIAN peoples living in urban counties compared with those in rural reservation counties. As in reservation communities, the greatest declines in hepatitis A incidence among AIAN peoples in urban counties occurred among children. Little is known about hepatitis A vaccination coverage among urban AIAN, but coverage is thought to be lower among children living in urban areas compared with those in rural reservation counties. The majority of AIANs who live outside of reservation communities receive health care at non-IHS facilities,[13,21,22] where the ACIP immunization recommendation for AIAN children may not have been implemented as early or as widely as in facilities in reservation communities, which serve a predominantly AIAN population. It is also possible that high rates of hepatitis A among urban AIANs in the past may have been linked to infections acquired because of contacts between urban and reservation communities, where hepatitis A was more prevalent. Thus, the decline in rates among AIAN peoples in urban areas might be the result, in part, of less HAV circulation in reservation areas.

This ecologic study has potential limitations. The counties included in the county-level analyses were selected because they were predominantly either rural or urban. However, we did not have information on the actual residence of cases within each county. Although none of the rural counties contained an urban area, misclassification could have occurred if a case-patient reported from an urban county resided in a rural part of the county. Because national surveillance data collected before 1990 did not include race/ethnicity-specific reporting, long-term data on trends in hepatitis A incidence among AIAN peoples are limited. It is unknown whether the peaks in hepatitis A incidence among AIANs nationwide that were seen in 1990 and 1995 represent a cyclical pattern of widespread epidemics. Hepatitis A incidence among AIAN peoples began declining in 1995, before the implementation of hepatitis A vaccination, and it is possible that the initial decline seen in hepatitis A incidence was the

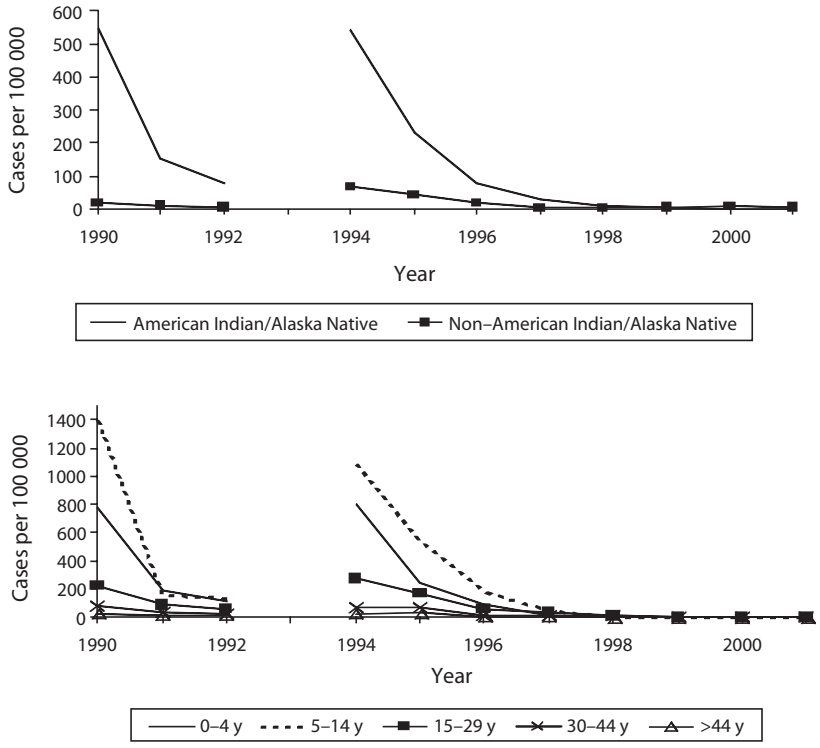

FIGURE 4—Hepatitis A incidence in 14 rural counties, (a) among American Indians and non–American Indians and (b) among American Indians/Alaska Natives, by age-group: 1990–2001.

result of a naturally occurring interepidemic period. However, because the periodicity of outbreaks varies among reservation communities, it seems plausible to attribute the sustained low incidence of hepatitis A among AIAN since 1997 to routine vaccination rather than to multiple prolonged and simultaneously occurring interepidemic periods.

The majority of hepatitis A cases in the United States are reported from communities that have consistently elevated rates of hepatitis A and from populations that are not predominantly AIAN.[1] The epidemiology of hepatitis A in these communities differs from AIAN communities in that the majority of the population, including older adolescents and adults, remains susceptible to HAV infection. Nonetheless, children often have the highest rates of disease and play an important role in HAV transmission by serving as sources of infection for susceptible adults in these communities.[23] In 1999, routine hepatitis A vaccination of children living in areas with consistently elevated rates was recommended as a long-term strategy to reduce overall hepatitis A incidence.[1] Overall declines in national rates in recent years are likely a reflection, at least in part, of the implementation of this strategy.[24,25]

The remarkable decline in hepatitis A incidence among AIANs coincident with increasing hepatitis A vaccination coverage indicates that there has been a fundamental alteration in hepatitis A epidemiology in AIAN communities. The disease has virtually disappeared from areas that historically had the highest hepatitis A rates in the United States. Sustaining high levels of hepatitis A vaccine coverage among AIAN peoples will be critical for maintaining low rates of hepatitis A in this population. ■

About the Authors

Stephanie R. Bialek is with the Division of Viral Hepatitis, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Ga. At the time of the study, Douglas A. Thoroughman was with the Division of Viral Hepatitis, National Centers for Infectious Diseases, Centers for Disease Control and Prevention and the Indian Health Service National Epidemiology Program. Diana Hu is with the Indian Health Service, Tuba City Indian Medical Center, Tuba City, Az. Edgar P. Simard and Beth Bell are with the Division of Viral Hepatitis, National Center for Infectious Diseases, Centers for Disease Control and Prevention. At the time of the study, Jody Chattin was with the Epidemiology Program Office, Centers for Disease Control and Prevention. Jim Cheek is with the Indian Health Service National Epidemiology Program, Albuquerque, NM.

Requests for reprints should be sent to Stephanie Bialek, Division of Viral Hepatitis, Mail Stop G-37, Centers for Disease Control and Prevention, 1600 Clifton Road, NE, Atlanta, GA 30333 (e-mail: zqg7@cdc.gov).

This article was accepted December 16, 2003.

Contributors

S.R. Bialek collected and analyzed the data and led the writing. D.A. Thoroughman assisted with data collection, analysis, and writing. D. Hu, E.P. Simard, and J. Chattin assisted with data collection. B. Bell and J. Cheek conceived the study. B. Bell supervised all aspects of its implementation. All authors helped to conceptualize ideas, interpret findings, and review drafts of the article.

Acknowledgments

We acknowledge the contribution of the children, families, and communities of the Navajo Nation and the Indian Health Service and other health care providers that care for these children, especially for their implementation of the hepatitis A vaccination program in this population. The authors also acknowledge Annemarie Wasley, Division of Viral Hepatitis, National Center for Infectious Diseases, Centers for Disease Control and Prevention, for assistance in accessing surveillance data.

Human Participant Protection

No protocol approval was needed for the analysis of trends in hepatitis A incidence, because the data are publicly available and contain no personal identifiers. The vaccination coverage survey was approved by the Navajo Nation human research review board.

References

1. Centers for Disease Control and Prevention. Prevention of hepatitis A through active or passive immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Morb Mortal Wkly Rep.* 1999;48:5–9.

2. Shaw FE, Shapiro CN, Welty TK, et al. Hepatitis transmission among the Sioux Indians of South Dakota. *Am J Public Health.* 1990;80:1091–1094.

3. Bulkow LR, Wainwright RB, McMahon BJ, et al. Secular trends in hepatitis A virus infection among Alaska Natives. *J Infect Dis.* 1993;168:1017–1020.

4. McMahon BJ, Beller M, Williams J, et al. A program to control an outbreak of hepatitis A in Alaska by using an inactivated hepatitis A vaccine. *Arch Pediatr Adolesc Med.* 1996;150:733–739.

5. Bell BP, Shapiro CN, Alter MJ, et al. The diverse patterns of hepatitis A epidemiology in the United States—implications for vaccination strategies. *J Infect Dis.* 1998;178:1579–1584.

6. Centers for Disease Control and Prevention. Hepatitis A vaccination programs in communities with high rates of hepatitis A. *MMWR Morb Mortal Wkly Rep.* 1997;46(26):600–603.

7. Centers for Disease Control and Prevention. Prevention of hepatitis A through active or passive immunization: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Morb Mortal Wkly Rep.* 1996;45:22.

8. Centers for Disease Control and Prevention. Summary of notifiable diseases, United States, 1999. *MMWR Morb Mortal Wkly Rep.* 1999;48:v–vii.

9. Centers for Disease Control and Prevention. Case definitions for infectious conditions under public health surveillance. *MMWR Morb Mortal Wkly Rep.* 1997;46:18.

10. US Census Bureau, Population Division, Population Estimates Program. Counties ranked by American Indian population in 1997. September 4, 1998. Available at: http://eire.census.gov/popest/archives/county/rank/aiea-r.txt. Accessed March 5, 2004.

11. US Census Bureau, Population Division, Population Estimates Program. 1990 to 1999 Annual Time Series of County Population Estimates by Race and Hispanic Origin. December 26, 2001. Available at: http://eire.census.gov/popest/archives/county/co_crh2.php. Accessed March 5, 2004.

12. US Census Bureau, Population Division, Population Estimates Program. 1990 to 1999 Annual Time Series of County Population Estimates by Age, Sex, Race, and Hispanic Origin. December 26, 2001. Available at: http://eire.census.gov/popest/archives/county/co_casrh.php. Accessed March 5, 2004.

13. US Census Bureau. *Statistical Abstract of the United States: 2000.* 120th edition. Washington, DC: US Census Bureau; 2000:45.

14. US Census Bureau. *Statistical Abstract of the United States: 2001.* 121st edition. Washington, DC: US Census Bureau; 2000:38.

15. US Census Bureau. American Factfinder. Available at: http://eire.census.gov/popest/data/states/tables/NST-EST2003-01.php. Accessed March 5, 2004.

16. US Census Bureau, Population Estimates and Population Distribution Branches. Preliminary Estimates of the Intercensal Population of Counties 1970–1979. April 1982. Available at: http://eire.census.gov/popest/archives/pre1980/e7080sta.txt. Accessed March 8, 2004.

17. US Census Bureau, Population Estimates and Population Distribution Branches. Intercensal Estimates of the Resident Population of States and Counties 1980–1989. April 1992. Available at: http://eire.census.gov/popest/archives/1990.php. Accessed March 5, 2004.

18. Centers for Disease Control and Prevention. *Hepatitis Surveillance Report 57.* Atlanta, Ga: Centers for Disease Control and Prevention, 2000:9–13.

19. Thoroughman DA, Bell BP, Cheek JE. *Knowledge, Attitudes, and Practices of Indian Health Service Hepatitis A Vaccination Providers—Winter, 1999–2000.* Internal Report. Albuquerque, NM: Indian Health Service National Epidemiology Program; 2001.

20. Smith PF, Grabau JC, Werzberger A, et al. The role of young children in a community-wide outbreak of hepatitis A. *Epidemiol Infect.* 1997;118:243–252.

21. US Department of Health and Human Services, Indian Health Service, Office of Public Health, Division of Community and Environmental Health, Program Statistics Team. *Regional Differences in Indian Health 1998–1999.* Rockville, Md; 2000:27.

22. US Department of Health and Human Services, Indian Health Service, Office of Public Health, Division of Community and Environmental Health, Program Statistics Team. *Trends in Indian Health 1997.* Rockville, Md; 1998:37.

23. Staes CJ, Schlenker TL, Risk I, et al. Sources of infection among persons with acute hepatitis A and no identified risk factors during a sustained community-wide outbreak. *Pediatrics.* 2000;106:e54.

24. Averhoff F, Shapiro CN, Bell BP, et al. Control of hepatitis A through routine vaccination of children. *JAMA.* 2001;286(23):2968–2973.

25. Samandari T, Wasley A, Bell B. Evaluating the impact of hepatitis A vaccination—United States, 1990–2001. Abstract presented at the 51st Annual Epidemic Intelligence Service Conference, Atlanta, Ga. April 22, 2002.

Subject codes 41, 61, 6