Infectious Disease Hospitalizations Among American Indian and Alaska Native Infants

Robert C. Holman, MS*; Aaron T. Curns, MPH*; James E. Cheek, MD, MPH†; Rosalyn J. Singleton, MD, MPH‡; Larry J. Anderson, MD§; and Robert W. Pinner, MD¶

ABSTRACT. Objective. To describe the burden and trends in hospitalizations associated with infectious diseases among American Indian and Alaska Native (AI/AN) infants.

Methods. First-listed infectious disease hospitalizations and hospitalization rates among AI/AN infants and infants in the general US population from 1988–1999 were analyzed by using Indian Health Service/tribal hospital discharge data and the National Hospital Discharge Survey data, respectively.

Results. Infectious disease hospitalizations accounted for 53% of all AI/AN infant hospitalizations and approximately 43% of all US infant hospitalizations during 1988–1999. The annual hospitalization rate for infectious diseases among AI/AN infants declined from 27,486 per 100,000 infants in 1988 to 14,178 per 100,000 infants in 1999. However, the rates for AI/AN infants within the Alaska, Southwest, and Northern Plains regions remained higher than that for the general US infant population at the end of the study period. Lower respiratory tract infection hospitalizations accounted for almost 75% of AI/AN infant infectious disease hospitalizations, and the lower respiratory tract infection hospitalization rate for AI/AN infants was twice that for US infants.

Conclusions. Although infectious disease hospitalization rates for AI/AN infants have declined, AI/AN infants continue to have a higher infectious disease burden than the general US infant population. Pediatrics 2003;111:176–182. URL: http://www.pediatrics.org/cgi/content/full/111/2/e176; infants, American Indians, Alaska Natives, infectious disease, hospitalizations, epidemiology.

ABBREVIATIONS. AI/AN, American Indian and Alaska Native; IHS, Indian Health Service; NHDS, National Hospital Discharge Survey; NCHS, National Center for Health Statistics; CI, confidence interval; SE, standard error; RR, risk ratio; LRTI, lower respiratory tract infection; RSV, respiratory syncytial virus.

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Infant hospitalization rates were calculated as the number of infant hospitalizations per 100 000 infants. Annual rates with 95% confidence intervals (CIs) were calculated for total (all hospitalizations), first-listed infectious disease, any-listed infectious disease, and specific infectious disease group infant hospitalizations. AI/AN population denominators were determined for each year of the study by using the IHS fiscal year 2001 user population estimates and adjusting retrospectively for annual changes in the IHS service region population (based on February 2002 IHS area estimates), excluding the IHS California and Portland areas.25,26 The user population includes all registered AI/AN patients who received IHS-funded health care service at least once during the last 3 years. The service population is an estimate of AI/ANs eligible for medical care through IHS or tribally operated facilities. Approximately 1.4 million AI/ANs, approximately 60% of all AI/ANs, are eligible for medical care from the IHS, which operates and provides funds for a network of inpatient and ambulatory care facilities across the continental United States and Alaska.2,9,25,26 AI/AN infants in this study represent AI/AN infants who received direct or contract health care through IHS or tribally operated facilities. Annual hospital fatality rates for both AI/AN infants and US infants were calculated as the number of infant deaths per 100 infant hospitalizations.

For the United States, rates for infants were calculated by using the NHDS with the US natality data as the denominator.27 Annual and overall standard errors (SEs) of NHDS estimates for 95% CI calculation were calculated by using SUDAAN software to account for the stratified sampling techniques.18,28 Denominators were considered free from sampling error.16,27 For both the AI/AN and US infants, the neonatal population was assumed to be 1/12 of the infant population and postneonatal composed the remaining 11/12 of the infant population.

Tests for trend were performed for the AI/AN infant rates by using linear regression,29 and a weighted least squares regression model was used for NHDS rates.30 Comparisons of age group, gender, and region among AI/AN infants were made for the most recent period (1998–1999) by using risk ratios (RRs) and 95% CIs. Comparisons of hospital length of stay for AI/AN infants were analyzed by using the Wilcoxon rank-sum test.31 For the US infants, length of stay was compared by using a t test based on ranks and adjusted for the survey design.28

RESULTS

Overall Rates and Trends

During 1988–1999, 35 793 infectious disease hospitalizations occurred among AI/AN infants. These hospitalizations represented 53.4% of total infant hospitalizations and 17.1% of infectious disease hospitalizations among all ages. For the general US population, infants accounted for 4 005 824 infectious disease hospitalizations, representing 43.0% (SE: 0.7%) of total infant hospitalizations and 8.2% (SE: 0.6%) of infectious disease hospitalizations for all ages. The annual hospitalization rate for infectious diseases among AI/AN infants declined 48.4% from 27 486 per 100 000 infants (95% CI: 26 742–28 242) in 1988 to 14 178 per 100 000 infants (95% CI: 13 672–14 699) in 1999 (P < .001; Fig 1A). The infectious disease rate among US infants did not change significantly during this period and ranged from 7284 (95% CI: 5514–9053) to 9640 (95% CI: 7470–11811) per 100 000 live births annually. The total hospitalization rate declined 51.0% for AI/AN infants and was stable for US infants (Fig 1A). The proportion of AI/AN hospitalizations attributable to infectious diseases was higher than that for the general US infant population during the study period, with 50.0% to 57.4% of AI/AN infant hospitalizations having an infectious disease compared with 36.8% (SE: 1.5%) to 47.4% (SE: 1.5%) of US infant hospitalizations (Fig 1B). During 1998–1999, the infectious disease hospitalization rate for AI/AN infants remained higher than that for the general US infant population (14 970 and 8996 per 100 000 infants, respectively; Tables 1 and 2). The infectious disease hospitalization rate for AI/AN infants was approximately 66% higher than that of the general US infant rate, whereas the overall hospitalization rate for AI/AN infants was also higher (37%) than the US infant estimate (Table 3). The hospitalization rate for any-listed infectious diseases during 1998–1999 was 18 186 per 100 000 AI/AN infants (95% CI: 17 787–18 592) and 11 175 per 100 000 US infants (95% CI: 8934–13 416).

Age, Gender, and Region

During 1988–1999, the annual rates of AI/AN infectious disease hospitalizations for neonates and postneonates declined similarly (P < .001; 48.7% and 41.8%, respectively; Table 1). The 1998–1999 infectious disease hospitalization rates for AI/AN neonates (16 217 per 100 000) and postneonates (14 856 per 100 000) were similar (RR: 1.09; 95% CI: 0.99–1.20). Furthermore, the hospitalization rate for AI/AN neonates was similar to that for US neonates during this period (14 154 per 100 000), whereas the rate for AI/AN postneonates was much higher than that for postneonates in the general US population (8527 per 100 000; Tables 1 and 2). The proportion of all hospitalizations with an infectious disease diagnosis was higher for AI/AN postneonates than for neonates (60.4% and 26.3%, respectively), and these proportions remained stable during the study period for both age groups.

In 1998–1999, the infectious disease hospitalization rate was higher for AI/AN male infants than for female infants (16 294 and 13 578 per 100 000, respectively; RR: 1.20; 95% CI: 1.14–1.27; Table 1). Rates for male AI/ANs and female AI/ANs were each approximately 40% higher than those for their US infant counterparts. The rate of infectious disease hospitalizations declined for both AI/AN male infants and female infants (P < .001), whereas the US infant rates did not change significantly during the study period. There was substantial variation in infectious disease hospitalization rates among AI/AN infants between regions (Table 1). The Alaska region had the highest hospitalization rate during 1998–1999, and, unlike all other regions, its rate did not change during the study period. Within the Alaska region, the
Hospitalization rate did not change during the study period for postneonates, whereas the rate for neonates declined. The Southwest region had the next highest hospitalization rate. The East and Northern Plains regions had the greatest rate decreases among AI/AN infants. The Oklahoma region had the lowest hospitalization rate throughout the study period. The hospitalization rates for Alaska, Southwest, and Northern Plains regions were significantly higher than the rate for the general US infant population.

**TABLE 1.** AI/AN Infant Infectious Disease Hospitalizations and Hospitalization Rates, IHS/Tribal, 1988–1999

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>No. of Hospitalizations</td>
<td>Rate (95% CI)*</td>
<td>No. of Hospitalizations</td>
<td>Rate (95% CI)*</td>
<td></td>
</tr>
<tr>
<td><strong>Age period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal</td>
<td>737</td>
<td>31 617 (29 708–33 526)</td>
<td>481</td>
<td>16 217 (14 918–17 605)</td>
</tr>
<tr>
<td>Postneonatal</td>
<td>6542</td>
<td>25 535 (25 003–26 074)</td>
<td>4839</td>
<td>14 856 (14 473–15 248)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4148</td>
<td>28 993 (28 252–29 745)</td>
<td>2967</td>
<td>16 294 (15 762–16 840)</td>
</tr>
<tr>
<td>Female</td>
<td>3131</td>
<td>22 948 (22 246–23 665)</td>
<td>2335</td>
<td>13 578 (13 074–14 099)</td>
</tr>
<tr>
<td><strong>Region†</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>132</td>
<td>23 404 (20 014–27 164)</td>
<td>70</td>
<td>7503 (5933–9432)</td>
</tr>
<tr>
<td>Northern Plains</td>
<td>1547</td>
<td>26 481 (25 356–27 636)</td>
<td>804</td>
<td>10 180 (9526–10 873)</td>
</tr>
<tr>
<td>Alaska</td>
<td>715</td>
<td>20 198 (18 894–21 567)</td>
<td>1058</td>
<td>23 569 (22 339–24 844)</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>439</td>
<td>7 325 (6685–8021)</td>
<td>411</td>
<td>5 602 (5092–6159)</td>
</tr>
<tr>
<td>Southwest</td>
<td>4446</td>
<td>37 013 (36 145–37 881)</td>
<td>2977</td>
<td>20 005 (19 367–20 659)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7279</td>
<td>26 042 (25 529–26 561)</td>
<td>5320</td>
<td>14 970 (14 601–15 346)</td>
</tr>
</tbody>
</table>

*Rate expressed as number of first-listed infectious disease hospitalizations per 100 000 American Indian/Alaska Native infants.
†Annual average user population by region for 1998–1999 as follows: East, 467; Northern Plains, 3949; Alaska, 2245; Oklahoma, 3669; and Southwest, 7441.
TABLE 2. US Infant Infectious Disease Hospitalizations and Hospitalization Rates, 1988–1999

<table>
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<tbody>
<tr>
<td>No. of Hospitalizations</td>
<td>Rate (95% CI)*</td>
<td>No. of Hospitalizations</td>
<td>Rate (95% CI)*</td>
<td></td>
</tr>
<tr>
<td>Age period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonatal</td>
<td>82 267</td>
<td>12 417 (9176–15 657)</td>
<td>93 199</td>
<td>14 154 (10 553–17 756)</td>
</tr>
<tr>
<td>Postneonatal</td>
<td>529 544</td>
<td>7266 (5716–8816)</td>
<td>617 574</td>
<td>8527 (6934–10 120)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>345 575</td>
<td>8487 (6634–10 339)</td>
<td>410 809</td>
<td>10161 (8212–12 110)</td>
</tr>
<tr>
<td>Female</td>
<td>266 236</td>
<td>6864 (5351–8378)</td>
<td>299 964</td>
<td>7775 (6275–9276)</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>112 577</td>
<td>7316 (5579–9054)</td>
<td>122 329</td>
<td>8883 (6379–11 386)</td>
</tr>
<tr>
<td>Midwest</td>
<td>142 868</td>
<td>7811 (4454–11 167)</td>
<td>146 014</td>
<td>8287 (4840–11 734)</td>
</tr>
<tr>
<td>South</td>
<td>186 964</td>
<td>6881 (5316–8445)</td>
<td>249 391</td>
<td>8723 (6126–11 319)</td>
</tr>
<tr>
<td>West</td>
<td>169 402</td>
<td>9082 (5308–14 655)</td>
<td>193 039</td>
<td>10 145 (5646–14 645)</td>
</tr>
<tr>
<td>Total</td>
<td>611 811</td>
<td>7695 (6048–9343)</td>
<td>710 773</td>
<td>8966 (7313–10 679)</td>
</tr>
</tbody>
</table>

* Rate expressed as number of first-listed infectious disease hospitalizations per 100 000 infants.
† Annual average census population by region for 1998–1999 as follows: Northeast, 4 409 659; Midwest, 5 397 820; South, 8 307 519; West, 5 790 281.

(Tables 1 and 2). In contrast to the IHS regions, the regional rates for US infants in the general population did not change significantly during the study period and did not differ by region.

Hospital Fatality Rate and Hospital Stay

The hospital fatality rate for infectious disease was 0.3% and was 0.5% for other hospitalizations among AI/AN infants, and both did not significantly change during 1988–1999. The hospital fatality rate for infectious disease was also 0.3% (SE: <0.1%) for infants in the general US population during the study period.

From 1988–1999, AI/AN infants and US infants accounted for 133 423 and 16 656 366 (SE: 1 562 150) days of infectious disease hospitalization, respectively. The median length of stay for infectious disease hospitalizations was 3 days for AI/AN infants during the study period. For other hospitalizations, the median length of stay decreased from 3 days in 1988–1989 to 2 days for 1998–1999 (P < .001). Among the general US infant population, the median length of stay for infectious disease hospitalizations decreased from 3 days in 1988–1989 to 2 days in 1998–1999 (P < .001). The proportion of hospital days associated with infectious disease diagnosis among AI/AN infants increased from 44.0% in 1988–1989 to 52.2% in 1998–1999. This proportion did not significantly change among US infants (27.9% [SE: 1.5%] in 1988–1989 and 31.9% [SE: 1.7%] in 1998–1999).

Approximately 4.4% of AI/AN infant infectious disease hospitalizations and 5.8% of other-cause hospitalizations resulted in a transfer to another facility. Transfers could not be discriminated between placement in another IHS or tribal facility or to a facility outside the IHS or tribal facilities. Among the US infants, approximately 2.0% (SE: 0.2%) of infant infectious hospitalizations and 5.1% (SE: 0.3%) of other-cause hospitalizations resulted in transfer.

Infectious Disease Groups

The hospitalization rates among AI/AN infants for each infectious disease group decreased during 1988–1999, except for that of the kidney, urinary tract, and bladder infections diagnostic group (Table 3). The hospitalization rate for the kidney, urinary tract, and bladder infections group also increased for the general population of US infants. The rate of hospitalizations was higher for AI/AN infants than for the general population of US infants for all infectious disease diagnostic groups, except the enteric infections and the other infectious diagnoses groups. The greatest disparity in rates between AI/AN and US infants was for lower respiratory tract infection (LRTI) hospitalizations, with the rate among AI/AN infants double that for US infants (10 853 vs 5293 per 100 000, respectively). For both AI/AN and US infants, LRTI hospitalizations accounted for the greatest proportion of infectious hospitalizations (72.5% and 58.8% [SE: 1.2%] during 1998–1999, respectively). LRTIs also accounted for the greatest proportion of AI/AN infant infectious disease hospital deaths during the 12-year study period (62.9% of 89 AI/AN infant deaths). Additional infectious disease categories with at least 1 hospital death among AI/AN infants were sepsis (10); kidney, urinary tract, and bladder infection (9); other infectious disease diagnoses (8); meningitis (2); upper respiratory tract infections (2); enteric infections (1); and viral central nervous system infections (1).

DISCUSSION

Although infectious disease hospitalizations rates declined among AI/AN infants, these rates remained higher than those for the general US infant population, highlighting the need for additional efforts to decrease infectious disease morbidity among AI/AN infants. The rate for AI/AN neonates approached that of the general US neonatal population at the end of the study period, but the rate for the AI/AN postneonatal population remained higher than that for the US postneonatal population. Among AI/AN infants, the disparity in the hospitalization rates for neonates and postneonates decreased during the study period, and the rates were similar by 1998–1999. At the end of the study period, AI/AN infant infectious disease hospitalization rates
### TABLE 3.  AI/AN and US Infant Hospitalizations and Hospitalization Rates by Infectious Disease Group, 1998–1999

<table>
<thead>
<tr>
<th>Infectious Disease Group</th>
<th>AI/AN (IHS/Tribal)</th>
<th>United States</th>
<th>Average Annual Rate Change, 1988–1999</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>Rate (95% CI)</td>
<td>Average Annual Rate Change, 1988–1999</td>
</tr>
<tr>
<td>Meningitis</td>
<td>22 (0)</td>
<td>62 (40–95)</td>
<td>−7.7</td>
</tr>
<tr>
<td>Septicemia</td>
<td>239 (4)</td>
<td>673 (591–764)</td>
<td>−4.2</td>
</tr>
<tr>
<td>Upper respiratory tract infections</td>
<td>279 (5)</td>
<td>785 (697–884)</td>
<td>−4.1</td>
</tr>
<tr>
<td>LRTI</td>
<td>3857 (73)</td>
<td>10 853 (10 533–11 182)</td>
<td>−3.0</td>
</tr>
<tr>
<td>Kidney, urinary tract, and bladder infections</td>
<td>330 (6)</td>
<td>929 (833–1035)</td>
<td>4.0</td>
</tr>
<tr>
<td>Enteric infections</td>
<td>113 (2)</td>
<td>318 (263–384)</td>
<td>−6.4</td>
</tr>
<tr>
<td>Viral central nervous system infections</td>
<td>56 (1)</td>
<td>158 (120–206)</td>
<td>−4.2</td>
</tr>
<tr>
<td>Other infectious diagnoses‡</td>
<td>354 (7)</td>
<td>996 (897–1106)</td>
<td>−5.2</td>
</tr>
<tr>
<td>Total infectious disease</td>
<td>5320 (54)</td>
<td>14 970 (14 601–15 346)</td>
<td>−3.5</td>
</tr>
<tr>
<td>Total hospitalizations</td>
<td>9768</td>
<td>27 486 (27 023–27 954)</td>
<td>−3.9</td>
</tr>
</tbody>
</table>

* Rate expressed as number of first-listed infectious disease hospitalizations per 100 000 infants.
† US hospitalization estimates <1 000 are not considered reliable.
‡ The 2 most frequent diagnoses within the other infectious category with their proportion contributed to 1998–1999 were IHS, unspecified viral infection (079.99; 2.0%) and bronchitis (490; 0.7%); NHDS, unspecified viral infection (079.99; 2.0%) and candidiasis of the mouth (112.0; 0.5%; unreliable estimate).
§ P < .01.
||P < .001.
ease hospitalization rate for AI/AN infants, the rate of hospitalization for the kidney, urinary tract, and bladder infections group increased by almost 50% during the study period. Among US infants, the rate for these infections increased 94%. Infections of these types are often suspected when an infant presents with a fever without other symptoms.42 It is not clear whether the increase in hospitalization rates for these types of infections reflect improved detection by physicians or represent a real increase among infants. However, the difference in the rate increase between the AI/AN and US infants is interesting and may warrant additional study. Another interesting finding was the lower enteric infections hospitalization rate for AI/AN infants as compared with US infants, which may be a result of the aggressive use of oral rehydration therapy in the IHS population.13

The data used in this study have limitations. AI/AN infants eligible for IHS/tribal services may obtain medical care outside the non–IHS-funded care, and this access may lead to an underestimate of the infectious disease burden among AI/AN infants. However, medical care accessibility, rural location, and free comprehensive care would encourage AI/ANs to seek IHS-funded medical care rather than non–IHS-funded care.9,13,25,26,43 The hospital fatality rate for AI/AN infants may underestimate the actual rate, because it does not reflect infants who may have died after being transferred to non–IHS-funded hospitals. IHS/tribal and US hospital diagnoses may be incomplete, inaccurate, or varied by region. In addition, hospital admission criteria may have varied within the IHS/tribal system, as well as between the IHS/tribal and the US populations. The US infant hospitalization rates are estimates derived from the NHDS, a complex, nationally representative sample of hospital discharges. These estimates necessarily have variability, and for some specific infectious disease groups, the estimates did not have a sufficient sample size to be considered reliable.21 Finally, AI/AN infants who received IHS-funded health care may not be representative of all AI/AN infants in the United States.

This study indicates the need for additional health services and early prevention measures for infectious diseases among AI/AN infants, such as those suggested in other studies.14,15,36,44–46 The increased infectious disease burden among AI/AN infants may be affected by lower socioeconomic status and limited access to health care in some IHS regions.4,12,32–34,47,48 It is likely that improved access to health services and continued emphasis in programs to promote childhood immunization,44–46,49,50 breastfeeding,32,46,51,52 and cessation of maternal smoking11,12,53 will reduce infectious disease hospitalizations in regions with high rates. Overall improvement in the socioeconomic status of AI/ANs is also likely to decrease infant infectious disease hospitalizations.5,9

This study described a decrease in the impact of infectious disease on AI/AN infant health during 1988–1999. However, infectious disease hospitalization rates among AI/AN infants within the Alaska and Southwest regions remained higher than that for the general US infant population. The disparities in hospitalization rates indicate that additional reductions in infectious disease hospitalizations among AI/AN infants are needed to obtain levels similar to that of the general US infant population and highlight an opportunity to improve the health status of AI/AN populations.

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