Asthma and Bronchiolitis Hospitalizations Among American Indian Children

Lenna L. Liu, MD, MPH; James W. Stout, MD, MPH; Marianne Sullivan, MPH; David Solet, PhD; David K. Shay, MD, MPH; David C. Grossman, MD, MPH

Objective: To compare asthma and bronchiolitis hospitalization rates in American Indian and Alaskan native (AI/AN) children and all children in Washington State.

Methods: A retrospective data analysis using Washington State hospitalization data for 1987 through 1996. Patients were included if asthma or bronchiolitis was the first-listed diagnosis. American Indian and Alaskan native children were identified by linking state hospitalization data with Indian Health Service enrollment data.

Results: Similar rates of asthma hospitalization were found for AI/AN children older than 1 year compared with all children. In AI/AN children younger than 1 year, hospitalization rates for asthma (528 per 100,000 population; 95% confidence interval [CI], 346-761) and bronchiolitis (2954 per 100,000 population; 95% CI, 2501-3456) were 2 to 3 times higher than the rates in all children (232 per 100,000 population [95% CI, 215-251] and 1190 per 100,000 population [95% CI, 1149-1232], respectively). Hospitalization rates for asthma and bronchiolitis increased 50% between 1987 and 1996 for all children younger than 1 year and almost doubled for AI/AN children younger than 1 year.

Conclusions: American Indian and Alaskan native children have significantly higher rates of hospitalization for wheezing illnesses during the first year of life compared with children of other age groups and races. Furthermore, the disparities in rates have increased significantly over time. Future public health measures directed at managing asthma and bronchiolitis should target AI/AN infants.


Asthma is the most common chronic disease of childhood. The rising prevalence and hospitalization rates for asthma have been well described in recent years. In addition, some studies have identified particular ethnic and racial groups as being disproportionately affected by asthma.

Few studies, however, have described asthma morbidity among American Indian and Alaskan native (AI/AN) children. The AI/AN population comprises 0.9% of the US population. Many AI/AN sociodemographic indicators are associated with higher rates of health problems; the AI/AN median family income is only 60% that of the total US population, and 27% of AI/AN families live in poverty compared with 10% of the general US population. However, unlike other impoverished populations, 60% of AI/ANs are eligible for unique health care services from the Indian Health Service (IHS).

One recent study of IHS hospitalizations reported AI/AN childhood asthma hospitalization rates that were comparable to rates in white children, despite adverse socioeconomic characteristics. The authors hypothesized that their findings might have been related to improved access to care provided by the IHS. Because risk of asthma hospitalization has been associated with lower socioeconomic status and urban residence, this study left unanswered whether urban AI/AN children have rates of asthma hospitalization comparable to their rural counterparts or to the rates among urban nonwhite children.

Research examining trends in childhood asthma incidence and prevalence is complicated by the difficulty in clinically distinguishing between asthma and bronchiolitis in early childhood, particularly during infancy. The diagnosis of asthma requires demonstration of chronicity and episodic reversible bronchospasm, most commonly manifested by wheezing. In infants, the most common cause of wheezing is bronchiolitis. Bronchiolitis, usually caused by infection with parainfluenza
PATIENTS AND METHODS

SETTING

Twenty-seven federally recognized tribes live in Washington State and account for 2% of the state population. The AI/AN population is younger than the population of the rest of the state: 40% of the AI/AN population is younger than 20 years compared with 29% of the rest of the state. The median family income for AI/ANs ($22,118) is 40% less than that of the rest of the state ($36,795), and 25% of AI/AN families have incomes below the poverty level compared with 8% of the rest of the state. Most AI/ANs in the state obtain their care through ambulatory clinics in tribal communities. Great variability in the organization of Indian health clinics is due to the amount of funding available and whether the tribe or the IHS operates the program. Clinics range from a large IHS-operated facility on the Yakama Reservation to areas where all Indian health care is contracted out to the private sector. Although Indian health clinics may be IHS affiliated, there are no inpatient IHS facilities in Washington State. All hospitalizations are at non-IHS hospitals and are included in the state database for inpatient hospitalizations. Because these hospitalization data do not contain codes for patient race or ethnicity, linkage with the IHS registry was used to identify IHS-registered AI/ANs.

DATA SOURCES AND LINKAGE

The Washington State Comprehensive Hospital Abstract Reporting System (CHARS) contains data for every discharge from all Washington State civilian, acute care, inpatient facilities. Each discharge record includes information on patient characteristics, up to 5 International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge diagnostic codes, insurance status, length of stay, and patient’s residential ZIP code. The first ICD-9-CM code indicates the primary reason for hospital admission. Each record also has a unique personal identification code composed of a segment of the patient’s first and last names and the date of birth.

The Portland Administrative Area of the IHS maintains a cumulative registration file of 64,590 individuals who have registered for IHS and tribal health services in Oregon, Washington, and Idaho as of 1996. The name and date of birth for each record was used to construct a unique identification code to match the code in CHARIS. Because the IHS file contains up to 3 first and last names for each individual (maiden names or aliases), codes were constructed for all possible combinations of names to maximize the possibility for linkage. Linkage was restricted to Washington State residents and enrollees who were indicated as Indian by a tribal code or degree of Indian blood. ZIP codes were examined for a subset of patients to validate the linkage. Based on the 1990 US Census and IHS registration data (midyear total) for Washington State, IHS enrollees represented approximately 72% of all AI/ANs identified by the 1990 US Census. Children (aged 0-17 years) were more likely to be registered with the IHS (82%) than adults (66%). This linkage process has been reported in previous studies.

PATIENTS

We linked IHS patient registration data files with records from the statewide hospital discharge data set that included a diagnosis of asthma (ICD-9-CM code 493) among children aged 0 to 17 years or bronchiolitis (ICD-9-CM code 466.1) among children aged 0 to 3 years. Through this linkage process, a new data set was created that consisted of asthma or bronchiolitis hospital discharge records for IHS-enrolled AI/ANs from 1987 through 1996. The comparison population consisted of all Washington hospital discharges among Washington residents of similar age groups and diagnoses during this period.

ANALYSIS

Asthma and bronchiolitis hospitalizations were identified by the primary discharge diagnosis in CHARIS. Rates of hospitalization were calculated per 100,000 population with VISTA/PH software. Age-specific analyses were performed for the following age groups: younger than 1, 1 to 4, 5 to 9, and 10 to 17 years. The denominator for AI/ANs was determined by annual midyear IHS registration population counts for Washington State AI/AN residents. Denominators for all children in Washington State were based on Washington intercensal estimates for each year. We were unable to separate AI/AN hospitalizations from the complete data set to compare the groups; however, given the small percentage of AI/AN hospitalizations relative to those for all other groups, this distinction should not affect the overall findings of this study. Because the complete number of IHS-registered AI/AN infants (aged <1 year) did not correlate with known birth rates after 1992, rates among this group were calculated only for 1987 through 1992. Hospitalization rates were compared by examining 95% confidence intervals (CIs) for overlap. The χ² test for trend was used to examine rates over time.

Repeat hospitalizations were counted in the overall rates. To account for the loss of independence due to multiple hospitalizations, we adjusted our results by the Multiple Admission Factor for pediatric asthma. The Multiple Admission Factor was designed using the Washington State hospitalization data (CHARS) for specific conditions to adjust for the extra variance introduced by multiple admissions when using hospitalization data that include multiple admissions. The 95% CIs and χ² statistics were adjusted by the Multiple Admission Factor.

The socioeconomic status of each patient was estimated using residential ZIP codes, which were grouped into 3 categories based on the proportion of the population living below the federal poverty level: less than 5% (low poverty), 5% to 19% (medium poverty), and 20% or more (high poverty). Patient ZIP codes were also used to classify urban or rural residence. “Urban” was defined as “comprising all territory, population, and housing units in urbanized areas and in places of 2500 or more persons outside urbanized areas.” ZIP codes in Washington State were divided into 50% or more urban (urban) and less than 50% urban (rural).

The study was approved by the institutional review boards of the University of Washington, the Washington State Department of Health, and the IHS.
or respiratory syncytial viruses, is common in the first year of life. Infants and young children may continue to have reactive airways or transient wheezing episodes after these infections.

Given these diagnostic limitations, some researchers have elected not to examine asthma in infants. However, those who have studied this age group have reported an increasing trend for asthma hospitalization. In infants and older children, these increases did not seem to be fully explained by a shift in coding from bronchiolitis or lower respiratory tract disease (such as bronchiolitis) to asthma. However, little is known about the incidence of bronchiolitis in AI/AN infants.

The purpose of our study was to characterize and compare rates of asthma and bronchiolitis hospitalizations in AI/AN children and all children in Washington State.

### RESULTS

#### ASTHMA

Approximately 23,500 children aged 0 to 17 years from the IHS patient registration data files comprised the AI/AN denominator. Between 1987 and 1996, 383 asthma hospitalizations occurred among Washington AI/AN children and 19,475 occurred among all Washington children (Table 1).

American Indian and Alaskan native children experienced similar overall rates of asthma hospitalization compared with all Washington State children (aged 0 to 17 years). Childhood asthma hospitalization rates increased during the 10 years for the state as a whole, although the AI/AN increase was not statistically significant ($\chi^2$ test for trend, $P<.001$ for Washington State; $P<.20$ for AI/ANs) (Figure 1). Results were similar when children aged 1 to 17 years were examined (data not shown).

Almost 50% of AI/AN asthma hospitalizations were multiple admissions during this period compared with 42% for all children. Medicaid was the primary payer for 62% of AI/AN childhood asthma hospitalizations in contrast to 34% of Washington childhood asthma hospitalizations. Using poverty levels based on the American Indian population in Washington ZIP codes, 33% of AI/AN

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**Table 1. Characteristics of Washington State Childhood Asthma and Bronchiolitis Hospitalizations, 1987-1996**

<table>
<thead>
<tr>
<th>Hospitalizations, No.</th>
<th>Asthma</th>
<th>Bronchiolitis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AI/AN (n = 383)</strong></td>
<td>All Races (n = 19,475)</td>
<td><strong>AI/AN (n = 487)</strong></td>
</tr>
<tr>
<td><strong>Primary payer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicaid</td>
<td>238 (62.1)</td>
<td>6724 (34.5)</td>
</tr>
<tr>
<td>Indian Health Service</td>
<td>30 (7.8)</td>
<td>312 (1.6)</td>
</tr>
<tr>
<td>Private/other</td>
<td>115 (30.0)</td>
<td>12,439 (63.9)</td>
</tr>
<tr>
<td><strong>Poverty level of patient residential ZIP code</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>125 (32.6)</td>
<td>2747 (14.1)</td>
</tr>
<tr>
<td>Medium</td>
<td>226 (59.0)</td>
<td>13,991 (71.8)</td>
</tr>
<tr>
<td>Low</td>
<td>10 (2.6)</td>
<td>2399 (12.3)</td>
</tr>
<tr>
<td><strong>Residence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>246 (64.2)</td>
<td>16,485 (84.6)</td>
</tr>
<tr>
<td>Rural</td>
<td>115 (30.0)</td>
<td>2652 (13.6)</td>
</tr>
<tr>
<td><strong>Length of stay, mean (SD), d</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>2.7 (1.5)</td>
<td>2.4 (1.9)</td>
</tr>
<tr>
<td>Female</td>
<td>159 (41.5)</td>
<td>7318 (37.6)</td>
</tr>
<tr>
<td>Age at hospital admission, y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1</td>
<td>72 (18.8)</td>
<td>2165 (11.1)</td>
</tr>
<tr>
<td>1-4</td>
<td>126 (32.9)</td>
<td>8849 (45.4)</td>
</tr>
<tr>
<td>5-9</td>
<td>91 (23.8)</td>
<td>4206 (21.6)</td>
</tr>
<tr>
<td>10-17</td>
<td>94 (24.5)</td>
<td>4255 (21.8)</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage) of children except where indicated otherwise. Numbers may not total because of missing values. AI/AN indicates American Indians and Alaskan natives; ellipses, not analyzed.*

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**Figure 1. Trends in asthma hospitalization rates for American Indian and Alaskan native (AI/AN) children and all children aged 0 to 17 years in Washington State, 1987 through 1996, 3-year rolling averages. Asterisk indicates $\chi^2$ test for trend, $P<.05$.**

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asthma hospitalizations occurred in residents of ZIP codes with high poverty, 59% occurred in those of ZIP codes with medium poverty, and 3% occurred in those of ZIP codes with low poverty (Table 1).

For both groups, rates of asthma hospitalization were higher in infants (aged <1 year) and children aged 1 to 4 years compared with 5- to 17-year-olds (Figure 2). Boys younger than 10 years were hospitalized more frequently than girls (data not shown).

Compared with the state, AI/AN children experienced similar asthma hospitalization rates in every age group except in infants (Figure 2). In infants, AI/ANs had significantly higher rates of asthma hospitalization (528; 95% CI, 346-761) compared with infants statewide (232; 95% CI, 215-251). There was also an increasing trend from 1987 through 1992 in infant asthma hospitalization rates in the state but a much steeper increase among AI/AN infants (χ² test for trend, P<.001 for Washington State; P<.05 for AI/ANs) (Figure 3).

Among all children, asthma hospitalization rates were highest in high poverty areas and lowest in low poverty areas (Table 2). However, the AI/AN hospitalization rates seemed to be inversely related to poverty, although these differences were not statistically significant (Table 2). Hospitalization rates were almost twice as high for state and AI/AN children in urban vs rural areas (Table 2). Results were similar when examined by age-specific hospitalization rates (data not shown).

**BRONCHIOLITIS**

There were 487 bronchiolitis hospitalizations among Washington AI/AN children and 14441 among all Washington children during the study period (Table 1). Bronchiolitis hospitalization rates were 5 times higher than asthma hospitalization rates for Washington State infants (all children: bronchiolitis, 1190 [95% CI, 1149-1232] vs asthma, 232 [95% CI, 215-251]). Rates of bronchiolitis hospitalization were 2.5 times higher for AI/AN children compared with the state (0- to 4-year-olds: AI/ANs, 2954 [95% CI, 2501-3456] vs all children, 1190 [95% CI, 1149-1232]). Furthermore, rates for AI/ANs increased during the study, particularly in infants (Figure 4).

Findings for bronchiolitis were similar to those for asthma when examined by sex, urban vs rural status, and poverty level. Boys had higher rates of bronchiolitis hospitalization than girls (data not shown). Bronchiolitis hospitalization rates in Washington were higher in urban than in rural areas for AI/ANs and all children in the state (Table 1). Rates for AI/ANs were comparable to those of the state in rural areas. However, in contrast to the asthma findings, rates of bronchiolitis hospitalizations in urban areas were higher in AI/AN children than in children in the state. Although high bronchiolitis hospitalization rates were associated with poverty in children statewide, AI/AN hospitalization rates did not vary significantly by poverty level (Table 2). As with asthma, age-specific bronchiolitis hospitalization rates stratified by poverty and urban vs rural status showed similar patterns to the total group (data not shown).

**COMMENT**

We found that IHS-enrolled AI/AN children older than 1 year have similar asthma hospitalization rates as all children in Washington State. Among infants, however, AI/AN asthma and bronchiolitis hospitalization rates are higher than those for all children, and these rates increased over time.

High bronchiolitis hospitalization rates in AI/AN infants have been reported previously. One recent study used national IHS data to examine bronchiolitis rates among IHS hospitals. They found hospitalization rates for AI/AN infants to be nearly double those for the general population (61.8 vs 34.2 per 1000 population). Our study complements this study by examining the Pacific Northwest region, which has no IHS inpatient facilities, and subsequently was not captured in their data.

We found that the higher AI/AN asthma hospitalization rate in 0- to 4-year-olds, a finding in previous studies, was driven by a marked increase in hospitalizations among AI/AN infants. These AI/AN infant asthma
hospitalizations might represent miscoded bronchiolitis, although asthma and bronchiolitis hospitalization rates increased concurrently during this period. A recent study\textsuperscript{39} using data from the US National Hospital Discharge Survey reported a statistically significant increase in infant bronchiolitis hospitalizations from 1988 through 1996 (P < .001, for trend), whereas hospitalizations for other lower respiratory tract diseases did not vary significantly (P = .20, for trend). Furthermore, we recently reviewed the charts of more than 200 infant asthma and bronchiolitis hospitalizations from an urban children’s hospital and found different epidemiologic patterns between asthma and bronchiolitis hospitalizations (Lessli Hornung, BS, University of Washington School of Medicine, written communication, September 28, 1999). Infants hospitalized for asthma and bronchiolitis differed in their age at admission, time of year of admission, and previous history of wheezing.

It is unclear why AI/AN infants have higher rates of asthma and bronchiolitis hospitalization. The high rates could be due to the presence of additional risk factors for lower respiratory tract disease. For example, AI/AN children may be more likely to develop lower respiratory tract disease because of possible environmental (tobacco or other indoor smoke exposure), sociodemographic (poverty and its effects on growth, nutrition, etc), or intrauterine (maternal smoking during pregnancy) effects. High rates of smoking prevalence among Pacific Northwest AI/ANs have been reported,\textsuperscript{30,31} notably among pregnant AI/AN women.\textsuperscript{34} One study\textsuperscript{34} found that from 1984 through 1988, 39.8% of all AI/AN women smoked during their pregnancy, a rate 1.3 times higher than that for Washington State white women (adjusted for age and marital status). Furthermore, maternal smoking has been shown to increase a child’s risk of respiratory virus infections, recurrent wheezing, and bronchiolitis.\textsuperscript{35-37} We did not have information on the family smoking status and were unable to consider this important factor in the analysis. Nonetheless, when hospitalizations for “wheezing lower respiratory tract disease” among AI/AN infants are considered as one entity, these infants bear a disproportionate burden of illness compared with those of other races and age groups.

Among older children, our asthma hospitalization results are similar to findings from previous studies. The Washington AI/AN asthma hospitalization rates (128 per 100 000 for 5- to 9-year-olds and 95 per 100 000 for 10- to 17-year-olds) were similar to rates among AI/AN children aged 5 to 17 years hospitalized in all IHS facilities between 1979 and 1989 (range, 50-80 per 100 000).\textsuperscript{12} However, these hospitalization rates were approximately half the rates for registered 5- to 14-year-old AI/ANs in Saskatchewan (256 per 100 000 in 1989).\textsuperscript{28} The comparable AI/AN asthma hospitalization rates for older children in contrast to the higher rates for AI/AN infants suggest that diagnostic substitution of bronchiolitis for asthma among AI/AN infants and recurrent wheezing after bronchiolitis within the first year of life are likely to be affecting the differences observed.

We also examined asthma hospitalization rates by urban vs rural status. Approximately 60% of the AI/AN asthma hospitalizations occurred in children living in urban ZIP code areas. Whereas asthma hospitalization rates for both groups were predictably higher in urban areas, rates among urban AI/ANs were lower than their urban all races counterparts.

This study has several limitations. Because we studied only AI/ANs registered with the IHS, these results might not be generalizable to all AI/ANs or IHS-registered AI/ANs living outside Washington State. Missclassification of ethnicity is also a potential limitation;

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**Table 2. Childhood Asthma and Bronchiolitis Hospitalization Rates by Poverty Level and Residence**

<table>
<thead>
<tr>
<th>Poverty level of patient residential ZIP code</th>
<th>Asthma (0- to 17-Year-Olds) AI/AN</th>
<th>All Races</th>
<th>Bronchiolitis (0- to 4-Year-Olds) AI/AN</th>
<th>All Races</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>135.6 (109.1-165.8)</td>
<td>257.8 (246.6-269.2)</td>
<td>527.7 (427.4-641.9)</td>
<td>792.9 (757.6-829.2)</td>
</tr>
<tr>
<td>Medium</td>
<td>168.7 (143.9-196.1)</td>
<td>206.4 (202.4-210.5)</td>
<td>743.7 (644.7-852.1)</td>
<td>470.4 (459.2-481.6)</td>
</tr>
<tr>
<td>Low</td>
<td>208.6 (182.2-240.4)</td>
<td>157.3 (149.9-164.7)</td>
<td>713.2 (626.3-1450.5)</td>
<td>286.6 (267.9-305.9)</td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>190.4 (163.6-219.9)</td>
<td>226.5 (222.5-230.5)</td>
<td>771.0 (667.6-884.2)</td>
<td>492.5 (481.6-503.5)</td>
</tr>
<tr>
<td>Rural</td>
<td>113.0 (90.0-139.3)</td>
<td>126.8 (121.2-132.5)</td>
<td>515.8 (422.9-622.0)</td>
<td>434.1 (414.0-454.8)</td>
</tr>
</tbody>
</table>

* Rates are expressed per 100 000 population (95% confidence interval). AI/AN indicates American Indians and Alaskan natives.
nonetheless, we are unaware of a better method to identify AI/AN children using secondary data without racial or ethnic identifiers. Another limitation was our inability to adjust for individual differences in socioeconomic status because ZIP code or payer were the only proxy variables available for socioeconomic status. We found that AI/AN asthma and bronchiolitis hospitalization rates did not differ significantly by poverty level in contrast to the corresponding rates statewide. It is possible that the poverty measure used did not accurately capture the level of poverty among AI/AN children and that relatively small numbers of AI/AN children limited our ability to detect differences.

Third, we only examined data for 1987 through 1991 for infants younger than 1 year because IHS enrollment figures for 1992 through 1996 did not correlate with known birth rates. Because it is likely that sick infants were disproportionately represented among IHS enrollees between 1992 and 1996, leading to artifactually high rates, we decided not to report these data. Finally, differences in practice patterns may explain the differences in hospitalization rates observed.38,39 Variation in hospitalization rates may be affected by physician discretion and health system attributes such as health insurance status, geographic distance from care facilities, physician-family relationships, or after-hours coverage systems.38

We conclude that asthma hospitalization rates for AI/AN children in Washington are similar to those for all children in the state except infants. AI/AN infants have disproportionately high rates of wheezing lower respiratory tract disease associated with asthma and bronchiolitis and could benefit from preventive measures such as a respiratory syncytial virus vaccine. Further studies are required to identify prenatal and postnatal factors predisposing this group to such high rates of hospitalization for infant wheezing and to examine long-term prognosis and sequelae.

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Corresponding author: Lenna L. Liu, MD, MPH, Child Health Institute, 146 N Canal St, Suite 300, Seattle, WA 98103-8652.

REFERENCES


