Socioeconomic Variation in Asthma Hospitalization: Excess Utilization or Greater Need?

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ABSTRACT. Objective. To assess the hypothesis that higher incidence of severe acute asthma exacerbation, not lower severity threshold for admission, explains the difference between the asthma hospitalization rates of inner-city and suburban children.

Methods. All 2028 asthma hospitalizations between 1991 and 1995 for children (aged >1 month and <19 years) dwelling in Rochester, New York, were analyzed. ZIP codes defined residences as inner-city, other urban, or suburban. Based principally on the worst oxygen saturation (SaO2) during the first 24 hours of hospitalization, severity was examined by hospital record review (n = 443) of random samples of inner-city, other urban, and suburban asthma admissions.

Results. Large inner-city/suburban differences were noted in many sociodemographic attributes, and there was also a distinct, stepwise gradient in risk factors in moving from the suburbs to other urban areas and to the inner city. Racial and economic segregation was particularly striking. Black individuals accounted for 62% of inner-city births versus <3% in the suburbs. Medicaid covered 65% of inner-city births, whereas Medicaid covered only 6% of suburban births.

The overall asthma hospitalization rate was 2.04 admissions/1000 child-years. Children <24 months old, those most commonly hospitalized for asthma, were fourfold more likely to be hospitalized (OR: 3.97, 95% CI: 3.44–4.57) than children between the ages of 13 and 18 years.

The hospitalization rate of asthma in boys was almost twice the rate of asthma in girls. The greatest gender difference was observed among children who were <24 months old. For these children, the rate for boys was 6.10/1000 child-years compared with 2.65/1000 child-years for girls (OR: 2.31, 95% CI: 1.95–3.03). This gender difference diminished gradually in older age groups to the extent that there was no difference among girls and boys between the ages of 13 and 18 years (males, 1.12/1000 child-years vs females, 1.09/1000 child-years).

Based on worst SaO2 values, mild (worst SaO2 ≥95%), moderate (90%–94%), and severe (<90%) admissions constituted 10.3%, 41.9%, and 47.7% of all hospitalizations, respectively. Although rates within the community followed a distinct geographic pattern of suburban (1.05/1000 child-years) < other urban (2.99/1000 child-years) < inner-city (5.21/1000 child-years), the proportions of admissions with low severity did not vary among areas. Likewise, the proportions of admissions that were severe (SaO2 <90%) were not significantly different (44.8, 45.7, and 52.1% for suburban, other urban, and inner-city areas, respectively). The distributions of asthma severity, measured by the duration of frequent nebulized bronchodilator treatments and the length of hospital stay, were also similar among children from different socioeconomic areas.

Conclusion. The marked socioeconomic and racial disparity in Rochester’s asthma hospitalization rates is largely attributable to higher incidence of severe acute asthma exacerbations among inner-city children; it signals greater need, not excess utilization. Both adverse environmental conditions and lower quality primary care might explain the higher incidence. Interventions directed at the environment offer the possibility of primary prevention, whereas primary care directed at asthma is focused on secondary prevention, principally on improved medication use.

Higher hospitalization rates cannot be assumed to identify opportunities for cost reduction. The extent to which our observations about asthma hold true under other conditions and in other communities warrants systematic attention. Knowledge of when higher rates signal excess utilization and when, instead, they signify greater needs should guide equitable national health policy.

ABBREVIATION. SaO2, oxygen saturation.

Wide variation in hospitalization rates for childhood asthma suggests that practice patterns have an important impact on hospitalization decisions, independent of asthma morbidity. Perrin et al found a fourfold difference among the asthma hospitalization rates of three urban areas in the northeastern United States: Boston, Massachusetts; New Haven, Connecticut; and Rochester, New York. Rates among counties in Maryland differed 10-fold, and a 16-fold difference in rates was observed among areas in New York City. Such geographic differences are ascribed commonly to variation among area-specific physician practice patterns or bed supplies, and are often believed to identify opportunities to reduce health care costs by altering practice patterns. Cost containment efforts proceed on the assumption that popu-
lations with high hospitalization rates have higher numbers of inappropriate admissions.

Although the impact of socioeconomic status on variations in use of health care resources has received relatively little attention, its potential importance to the validity of this approach to health care cost containment is substantial. Socioeconomic status is correlated highly with child health status and the likelihood of childhood hospitalization. Impoverished inner-city children may be hospitalized for asthma more commonly than suburban children because of greater morbidity burden; their incidence of severe asthma episodes may be greater because of a higher prevalence of asthma, lower quality of health care, or adverse environmental factors. High asthma hospitalization rates for inner-city children might reflect increased exposure to specific antigens such as those associated with cockroach infestation, air pollution, racial or genetic factors, or suboptimal use of antiinflammatory therapies for children with mild or moderate asthma. However, practice patterns may also contribute significantly to socioeconomic variations in asthma hospitalization rates. Providers might apply a lower severity threshold for hospitalization of children of lower socioeconomic groups. Concerned about the ability of a disadvantaged family to care for a child with an asthma exacerbation at home, a physician might hospitalize that child for a less severe asthma exacerbation than an asthmatic home, a physician might hospitalize that child for a less severe asthma exacerbation than an asthmatic child whose family has greater resources. Identifying the basis of inner-city/suburban differences is important because of the potential implications for health care financing, for strategies to reduce morbidity burden, and for clues about the basis of the recent increase in asthma morbidity and mortality in all levels of society.

To investigate the contributions of disease severity and variation in practice patterns to the differences between inner-city and suburban hospitalization rates for asthma, we focused on Monroe County (Rochester), New York. In this community, the majority of children from all geographic areas and socioeconomic strata are hospitalized in two hospitals that are equidistant from the inner city, are staffed by physicians from a single pediatric training program, and provide a standard approach to the management of children with asthma. We compared rates of low severity admissions for asthma among children living in areas with markedly different asthma hospitalization rates to evaluate the possibility that higher hospitalization rates were associated with higher rates of inappropriate admission. Our specific objectives were 1) to examine variation in asthma hospitalization rates among different socioeconomic areas within Rochester and 2) to assess the hypothesis that higher incidence of severe illness episodes, not lower severity threshold for admission, explains the differences in asthma hospitalization rates between inner-city and suburban children.

**METHODS**

**Study Population**

Analysis was based on all hospitalizations for children dwelling in Rochester, New York, who were >1 month and <19 years of age when they were admitted during the study period of January 1991 through December 1995. Data were obtained from the Rochester Hospitals database, a dataset that was developed and maintained cooperatively by all Rochester area hospitals.

Size of populations at risk in each socioeconomic area was determined from 1990 US Census data, which is broken down by ZIP code. As in previous studies, ZIP codes and proportion of births covered by Medicaid were used to divide Rochester into three socioeconomic areas: inner-city, other urban, and suburban. Inner city was defined as ZIP codes for which the largest portion of births were covered by Medicaid. Other urban was defined by ZIP codes not in the inner city, but with the majority of births to city dwellers. Suburban included the remaining areas in the county. Characteristics of socioeconomic areas were determined from the birth certificate records of Rochester for 1989 and 1990 and from the 1990 US Census. As shown in Table 1, our use of Medicaid births as the basis for distinguishing inner-city areas from other urban areas identified environs with markedly different social and demographic characteristics. Suburbs were markedly different from both areas of the city.

**Medical Record Reviews**

Detailed clinical information for characterizing illness severity was obtained by medical record review. Random samples of asthma hospitalizations were drawn from all three socioeconomic areas, but sampling strategy emphasized suburbs and inner city because of the primary interest in comparisons between these two areas. Samples drawn from the inner city (n = 192) and the suburbs (n = 181) represented 26% of admissions from these two areas. A smaller (12%) sample was drawn for other urban area admissions (n = 70). Characteristics of patients from these different areas provided the opportunity to demonstrate a dose-response effect, because its socioeconomic attributes fall between those of the suburbs and the inner city. Altogether, 443 records were reviewed, constituting an overall sampling fraction of 22%. Random samples were drawn from only two of the three hospitals in Rochester that cared for children with asthma. Medical conditions at two Rochester hospitals, a tertiary care university hospital and a closely affiliated community hospital, accounted for 91.0% of suburban, 90.0% of other urban, and 91.2% of inner-city asthma hospitalizations.

**Definitions**

Asthma hospitalizations were defined by a primary discharge diagnosis coded between 493.0 and 493.91 according to the International Classification of Diseases, 9th Revision, Clinical Modification. The primary measure of asthma severity was based on oxygen saturation (SaO2) level. Worse episodes were defined as the lowest SaO2 obtained in the first 24 hours of hospitalization at a time when the child was receiving no supplemental oxygen. Because of the large number of SaO2 values obtained in the first 24 hours for most of the children who were admitted, only the best and worst values for both the emergency department and inpatient were abstracted from the record. We recorded three different SaO2 values in the first 24 hours for >90% of episodes.

Similar to previous studies, mild, moderate, and severe asthma episodes were defined based on worst SaO2 values of ≥95%, 90% to 94%, and <90%. At least one SaO2 at room air was recorded in the first 24 hours for 433 (98%) of the 443 episodes. Among the remaining 10 episodes, seven in which the worst SaO2 was obtained despite supplemental oxygen were assigned to the most severe category. Three episodes in which worst SaO2 values were normal but high levels of supplemental oxygen (50%–100%) were administered were also assigned to the most severe category. For these 3 children, admitted directly to the critical care unit, it was apparent that failure to obtain SaO2 values from supplemental oxygen in the first 24 hours of admission was attributable to extreme severity. Nursing shifts were used in this analysis as the primary unit of time because of their implications for hospital staffing. Nursing shifts were defined for study purposes as 8-hour periods in an inpatient unit, beginning with the time of arrival. Periods of ≥4 hours were counted as a full nursing shift, because nurses generally work full shifts. The first 24 hours of hospitalization were defined as the entire emergency department stay plus three nursing shifts in an inpatient unit.

Other measures of severity included the hospital length of stay, which was defined as the number of hours from the first nebulized medication administration in the inpatient unit until noon on the
day of discharge, and the duration of frequent nebulized medications, which was defined by the number of 4-hour periods in which nebulized medication was administered two or more times. Data on nebulized medication administration were available for 434 (98%) of the 443 cases. Virtually all nebulized medication that were administered during the study period was albuterol.

Analysis

Before data collection, general pediatric and pediatric pulmonary colleagues decided that a difference of 15 percentage points between inner-city and suburban children admitted with mild asthma was clinically important. With the number of records reviewed in inner-city and suburban samples, there was a power of 97% to detect a population difference of 15 percentage points (10%–25%) between these two areas, and a power of 77% to detect a population difference of 10 percentage points (10%–20%).

The primary focus of analysis was the asthma hospitalization rates that were presented as events per 1000 child-years. Based on the Poisson distribution, the rate for each community was calculated by dividing the number of hospitalizations by the population and multiplying by 1000. The calculation of this rate, each child in the census increased the count by 5 child-years because each represented a child who had been at risk for hospitalization for 5 years. Analysis was also performed that focused on the hospitalization of a particular child (identified by medical record number) for asthma. This event provided the numerator for asthma hospitalization rates. In determining these rates, only one asthma hospitalization during the observation period was counted for a particular child. Each child identified in the 1990 US Census increased the denominator count by 1 child for calculations of the asthma-patient hospitalization rate.

Risk for hospitalization among socioeconomic areas was compared using ORs. CIs for ORs were calculated using Woolf’s method. The calculation of SEs for rates was based on the Poisson distribution. The t test was used to assess statistical significance for differences between 2 means and the F test was used to assess significance for differences among means of multiple groups.

RESULTS

Characteristics of Socioeconomic Areas

Striking inner-city/suburban differences were noted in many characteristics (Table 1), and there was also a distinct, stepwise gradient in risk factors in moving from suburbs to other urban areas and to the inner city. Racial and economic segregation is particularly striking. Black individuals accounted for 62% of inner-city births versus 3% in the suburbs. Medicaid covered 65% of inner-city births, whereas Medicaid covered only 6% of suburban births. Similarly, among hospital admissions from inner-city, other urban, and suburban areas 57.7%, 35.7%, and 6.5%, respectively, were of black children, and 62.4%, 50.1%, and 13.1%, respectively, of admissions were covered by Medicaid insurance.

Hospitalization for Asthma

Among the 29329 hospital admissions of children in Rochester during the study period, 2028 a primary diagnosis of asthma. The county-wide asthma hospitalization rate was (95% CI: 1.95–2.13) 2.04 admissions/1000 child-years. Based on worst SaO2 values, mild, moderate, and severe admissions constituted 10.3%, 41.9%, and 47.7% of all hospitalizations, respectively. Rates varied substantially by age and gender, as shown in Fig 1. Children <24 months old, those most commonly hospitalized for asthma, were

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TABLE 1. Socioeconomic Areas and Their Attributes

<table>
<thead>
<tr>
<th>Units</th>
<th>Socioeconomic Areas</th>
<th>Suburbs</th>
<th>Other Urban</th>
<th>Inner City</th>
<th>County Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denominator</td>
<td>1990 Census, age &lt;19 y</td>
<td>N</td>
<td>130265</td>
<td>39595</td>
<td>28733</td>
</tr>
<tr>
<td>Attributes of socioeconomic area*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No health insurance</td>
<td>%</td>
<td>1.0</td>
<td>1.5</td>
<td>1.7</td>
<td>1.3</td>
</tr>
<tr>
<td>Medicaid-covered births</td>
<td>%</td>
<td>5.7</td>
<td>26.8</td>
<td>65.0</td>
<td>24.7</td>
</tr>
<tr>
<td>Prepaid health insurance</td>
<td>%</td>
<td>72.2</td>
<td>57.4</td>
<td>27.0</td>
<td>56.5</td>
</tr>
<tr>
<td>Prenatal care started month 6 or later</td>
<td>%</td>
<td>2.2</td>
<td>6.4</td>
<td>14.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Low birth weight (&lt;2500 g)</td>
<td>%</td>
<td>4.8</td>
<td>7.2</td>
<td>11.9</td>
<td>7.1</td>
</tr>
<tr>
<td>Mother’s age &lt;19 y</td>
<td>%</td>
<td>2.3</td>
<td>7.2</td>
<td>17.6</td>
<td>7.2</td>
</tr>
<tr>
<td>Mother’s education &lt;high school</td>
<td>%</td>
<td>5.7</td>
<td>19.7</td>
<td>43.4</td>
<td>18.4</td>
</tr>
<tr>
<td>Mother smoked during pregnancy</td>
<td>%</td>
<td>14.3</td>
<td>24.4</td>
<td>28.8</td>
<td>20.8</td>
</tr>
<tr>
<td>Mother black</td>
<td>%</td>
<td>2.6</td>
<td>20.8</td>
<td>61.8</td>
<td>21.2</td>
</tr>
<tr>
<td>Mother Hispanic</td>
<td>%</td>
<td>1.2</td>
<td>4.1</td>
<td>16.2</td>
<td>5.3</td>
</tr>
<tr>
<td>Housing units with no phone</td>
<td>%</td>
<td>7.7</td>
<td>4.4</td>
<td>13.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Housing units with no automobile</td>
<td>%</td>
<td>4.6</td>
<td>19.1</td>
<td>42.0</td>
<td>12.2</td>
</tr>
<tr>
<td>Children &lt;5 y old living in poverty</td>
<td>%</td>
<td>5.3</td>
<td>28.7</td>
<td>56.5</td>
<td>19.2</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td></td>
<td>Mean</td>
<td>3.8</td>
<td>7.9</td>
<td>14.3</td>
</tr>
<tr>
<td>Per capita income</td>
<td>$</td>
<td>18210</td>
<td>13605</td>
<td>8386</td>
<td>16089</td>
</tr>
<tr>
<td>Hospitalization for asthma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>N</td>
<td>687</td>
<td>591</td>
<td>748</td>
<td>20265</td>
</tr>
<tr>
<td>Covered by Medicaid</td>
<td>%</td>
<td>13.1</td>
<td>50.1</td>
<td>62.4</td>
<td>42.7</td>
</tr>
<tr>
<td>Asthma hospitalization rate†</td>
<td>N</td>
<td>1.05</td>
<td>2.99</td>
<td>5.21</td>
<td>2.04</td>
</tr>
<tr>
<td>SE of rate</td>
<td>N</td>
<td>.04</td>
<td>.12</td>
<td>.19</td>
<td>.05</td>
</tr>
<tr>
<td>Asthma-patient hospitalized rate‡</td>
<td>N</td>
<td>4.00</td>
<td>10.25</td>
<td>17.92</td>
<td>7.27</td>
</tr>
<tr>
<td>SE of rate</td>
<td>N</td>
<td>.18</td>
<td>.51</td>
<td>.79</td>
<td>.19</td>
</tr>
<tr>
<td>Hospitalization records reviewed</td>
<td>N</td>
<td>181</td>
<td>70</td>
<td>192</td>
<td>43</td>
</tr>
<tr>
<td>Sampling fraction</td>
<td>%</td>
<td>26.3</td>
<td>11.8</td>
<td>23.7</td>
<td>21.8</td>
</tr>
</tbody>
</table>

* Except for the last five attributes listed, which were based on US Census data, attributes of socioeconomic areas were based on Monroe County birth certificate data and, thus, represent characteristics of new mothers in these areas.
† Number of admissions per 1000 child-years at risk, 5-year observation period.
‡ Number of patients hospitalized for asthma 1 or more times per 1000 children at risk during the 5 years of observation.
§ Two admissions lacked ZIP code data and therefore could not be assigned to a socioeconomic area.
fourfold more likely to be hospitalized (OR: 3.97, 95% CI: 3.44–4.57) than those least likely, children between the ages of 13 and 18 years. The hospitalization rate for asthma in boys (2.65/1000 child-years) was almost twice that of girls (1.43/1000 child-years). The greatest gender difference was observed among children <2 years old. For these children, the rate for males was 6.10/1000 child-years compared with 2.65/1000 child-years for females (OR: 2.31, 95% CI: 1.95–3.03). This gender difference diminished gradually in older age groups to the point that there was no difference among those boys and girls between the ages of 13 and 18 years (males, 1.12/1000 child-years vs females, 1.09/1000 child-years).

Variation in Hospitalization Among Socioeconomic Areas

Asthma hospitalization rates for the socioeconomic areas also followed a stepwise gradient, with rates (95% CI) per 1000 child-years, of 1.05 (.98 –1.13), 2.99 (2.74 –3.23), and 5.21 (4.83–5.58) for suburban, other urban, and inner city, respectively. These hospitalization rates are represented by the width of the bars in Fig 2. Using the odds for hospitalization of suburban children as the base odds, the odds of hospitalization for other urban children was almost triple the odds of hospitalization for suburban children (OR: 2.84, 95% CI: 2.74 to 3.23), and the odds of hospitalization for inner-city children was nearly five times the odds of hospitalization for suburban children (OR: 4.96, 95% CI: 4.83–5.58).

The analysis in which hospitalizations for each socioeconomic area were broken down by severity, as defined by worst $\text{Sa}_O_2$, suggested there was no difference among areas in severity threshold for admission. As Fig 2 illustrates, mild episodes constituted 10.4%, 10.0%, and 10.5% of asthma hospitalizations for inner-city, other urban, and suburban areas, respectively. The proportion of episodes that were severe was likewise very similar among areas, ranging from 44.8% for the suburbs to 45.7% for other urban and to 52.1% for inner-city areas. No difference in severity distribution between any two areas was statistically significant.

Analysis in which severity was classified based on length of stay also provided results that were consistent with the hypothesis that there was no lowering of severity threshold for admission of children from lower socioeconomic areas. In fact, inner-city children were hospitalized on average 19.1% longer than suburban children, 55.6 hours versus 45.7 hours ($t = 2.79, P < .01$). There was no difference in mean length of stay between other urban children and suburban children (47.3 hours vs 45.7 hours, $t = .38$, not significant). Analysis of the duration of frequent nebulized medications demonstrated a pattern consistent with this hypothesis as well. For inner-city children, the mean number of 4-hour periods receiving frequent nebulized medications was marginally greater than that for suburban children (3.66 vs 6.96 periods, $t = 2.84, P < .01$). There was no difference in mean length of stay between other urban children and suburban children (47.3 hours vs 45.7 hours, $t = .38$, not significant). Analysis of the duration of frequent nebulized medications demonstrated a pattern consistent with this hypothesis as well. For inner-city children, the mean number of 4-hour periods receiving frequent nebulized medications was marginally greater than that for suburban children (3.66 vs 6.96 periods, $t = 2.84, P < .01$).

To assess the possibility that differences in practice patterns between the two hospitals might account for key findings, separate analyses were conducted for each hospital. At the tertiary care hospital, the proportions of children from inner-city, other urban, and suburban areas with severe asthma were virtually identical (42.1%, 45.8%, and 44.6%, respectively; $\chi^2 = .26, P = \text{not significant}$). At the community hospital, the proportion of children from the inner city with severe asthma was greater than the proportion of children from other urban areas and from the suburbs (64.7% vs 45.5% and 45.0%, respectively; $\chi^2 = 6.05; P < .05$). Although oximetry values suggested there were small differences in practice patterns between these two hospitals, there was no suggestion in severity distributions of a lower severity threshold for admission of inner-city children at either hospital.

Agreement Among Measures of Severity

The mean length of stay for all asthma admissions was 50.3 hours. For episodes classified based on
worst \( \text{SaO}_2 \) as mild, moderate, and severe, the mean length of stay in hours was 38.9, 46.5, and 55.7, respectively \( (F = 6.5, P = .002) \). The mean number of periods with frequent nebulized medications for all asthma admissions was 3.98. For episodes classified based on worst \( \text{SaO}_2 \) as mild, moderate, and severe, the mean number of periods receiving frequent nebulized medications was 2.20, 3.34, and 4.92, respectively \( (F = 9.2, P \leq .001) \).

**Asthma-Patient Hospitalized Rates**

A total of 1444 children accounted for the 2028 hospital admissions for asthma. The mean number of asthma hospitalizations for these children was 1.40; 77.1% of patients were hospitalized for asthma only once during the 5-year observation period and 91.3% were hospitalized for asthma no more than twice. The extent of clustering of hospital admissions varied little among socioeconomic areas. Multiple admissions occurred in 23.9%, 24.4%, and 20.7% of inner-city, other urban, and suburban children hospitalized for asthma during the study period, respectively. Of note, the mean number of asthma hospitalizations for inner-city children (1.47) was significantly greater \( (t = 2.37, P < .02) \) than for suburban children (1.32). For other urban children hospitalized for asthma, mean hospitalizations (1.43) was marginally greater \( (t = 1.84, P = .07) \) than for suburban children.

Variation in asthma-patient hospitalized rates by socioeconomic area followed a pattern similar to the asthma hospitalization rates presented above. Overall asthma-patient hospitalized rate (95% CI) was 7.27 (6.90–7.65) per 1000 children and varied from 4.00 (3.66–4.34) for the suburbs to 10.25 (9.26–11.25) and to 17.92 (16.38–19.47) in other urban and inner-city areas, respectively.

**DISCUSSION**

**Explaining Variation in Hospitalization Rates**

Our finding of a fivefold greater rate of hospitalization for asthma among inner-city children agrees with findings of previous studies in which lower socioeconomic status was associated with increased severity and likelihood of hospitalization for asthma.²³⁶ Plausible hypotheses explaining the socioeconomic variation in rates for children in Rochester may be grouped as morbidity burden hypotheses, primary care sensitivity hypotheses, and health system hypotheses.⁸ Morbidity burden hypotheses contend that variations in hospitalization rates result from differences in morbidity rates and distribution of severity among socioeconomic areas. Primary care sensitivity hypotheses assert that several components of high-quality primary care, including prevention, early intervention, careful follow-up, and more effective illness management at the point of first contact might reduce hospitalization rates. Studies suggesting that hospitalization for asthma and other conditions is sensitive to the quality of primary care support this group of hypotheses.¹⁴,¹⁵ In the Boston area, minority children who were hospitalized for asthma were less likely to receive care that might have prevented admission and less likely to be discharged with plans judged appropriate for subsequent care.¹⁶ Variation in hospitalization rates for ambulatory care sensitive conditions has been recognized previously as a key indicator of health care access or quality.¹²–¹⁴ Health care system hypotheses maintain that components of the health care system other than primary care explain variations in hospitalization rates. Other components might include geographic distance, transportation, and communication systems, or area-specific practice style. Severity threshold for admission may be viewed as a component of an area’s practice style that might be influenced by provider characteristics, insurance type, and provider-parent interactions. Health care system hypotheses are supported by studies finding that bed supply and proximity to hospitals influence hospitalization rates.⁶,¹⁷ These three groups of hypotheses are not mutually exclusive. For example, reasons for a higher level of morbidity burden might be delayed intervention and poor follow-up, which are characteristics of lower quality primary care.

**Variation in Admission Threshold**

Among these hypotheses, this study addresses two, morbidity burden and admission threshold. In theory, a lower severity threshold for admission, a higher incidence of severe illness episodes, or both might explain higher rates of asthma hospitalization in a population group. Our data strongly suggest that health care system characteristics, including se-

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Fig 2. Hospitalized acute asthma exacerbation: severity distribution and hospitalization rates. Bar widths reflect hospitalization rates (per 1000 child-years).
verity threshold for admission, explain few or none of the observed differences in asthma hospitalization rates in Monroe County. Bed supply and practice style, two prominent health system characteristics, vary little within this community. Although rates of hospitalization were dramatically different, no differences were found in the severity distributions for hospitalizations among the three socioeconomic areas.

Variation in Hospitalization Attributable to Variation in Morbidity Burden

Instead, the large difference between inner-city and suburban hospitalization rates seems to be attributable to differences in morbidity burden. The relative contributions to morbidity burden differences of genetic factors, environmental factors, and quality of primary care could not be addressed in this study. However, a previous study in this community suggested that hospitalization rates for conditions that were clearly constitutional in nature varied little among the three socioeconomic areas.18,19 Other studies have shown higher rates of prevalence and hospital admission related to asthma for black and Hispanic individuals,3,20 but many of these differences have been attributed to lower socioeconomic status rather than to an innate predisposition.2

The fact that asthma is rare among children in rural African villages21,22 and common among blacks in the United States strongly supports the idea that genetic differences alone cannot explain differences in morbidity burden.

Environmental effects on morbidity burden are of primary concern. Social and physical environments vary widely across socioeconomic areas, and a large body of evidence supports the idea that they play a substantial role in the etiology or exacerbation of asthma.23–27 Evidence supports several mechanisms for increased morbidity burden among lower socioeconomic children. Mechanisms may involve increased exposure to environmental tobacco smoke, household crowding, older siblings with viral illness, social stress, and multiple allergens (eg, cockroach, dust mites).28–38 The degree of variation in asthma hospitalization rates (inner-city/suburban OR: 4.96), which is high compared with effect sizes typical for single environmental exposures, also supports the idea that genetic differences alone cannot explain differences in morbidity burden.

Although limited access to high quality primary care is another consideration, high levels of access to primary care across socioeconomic areas in Rochester may not be up to the task of ensuring optimal environmental control and optimal medication use in some impoverished households. For many inner-city children with asthma, enhanced primary care may be required to prevent progression to a stage of illness in which emergency department or inpatient care is necessary. Less antiinflammatory medication use12,16 and fewer physician office visits43 have been associated with higher asthma hospitalization rates. Conversely, increased inhaled corticosteroid use has been associated with decreased hospitalization rates.44–46 However, it should be recognized that randomized clinical trials to assess the effectiveness of primary care visits or antiinflammatory medication in reducing hospitalization for asthma among inner-city children have not been published.

Limitations and Implications for Additional Research

Some observations may be unique to this community. Practice patterns in Monroe County may be more homogeneous than elsewhere. One cannot draw firm inferences about all acute asthma exacerbations from an inpatient sample. Patterns observed among inpatients may not be consistent over a milder range of severity.

Measurement issues should be considered also. No single observation such as worst SaO₂ can capture fully a multidimensional construct such as severity of an acute illness episode. We used worst SaO₂ as the primary measure of severity, because it is reproducible, commonly used in clinical settings, and directly reflects derangement in pulmonary function. Two observations that were tied more closely to the duration of the illness episode, length of stay, and duration of frequent nebulized medications confirmed findings based on worst SaO₂.

Among wheezing children <24 months old, the diagnosis of asthma is questioned sometimes, and use of this diagnostic label might vary widely. However, conclusions remain whether analysis includes observations in this youngest age group. Although differences among socioeconomic areas were greatest among children <24 months of age (Fig 2), they remained high among children in older age groups in which disagreement on diagnosis is unusual. Also of note, it is generally accepted that asthma occurs commonly in the first 2 years of life. Thus, although generalizability of our findings in this age group is uncertain because of variability in the diagnosis of asthma, asthma hospitalization patterns in the first 2 years of life are important.

Although our focus was asthma hospitalization rates for geographically defined populations, we also calculated asthma-patient hospitalized rates. The primary purpose in performing this calculation was to examine clustering of hospitalizations in children. Hospitalization rates and patient rates differ in part because they use different denominators. Hospitalization rates use populations of all children in an area at one point in time, typically provided by census data. True denominators for patient rates are provided by a list of children under continuous observation for a specified period of time, typically
provided by health insurance enrollment files. Hospitalization rates reflect an ecological or community perspective, whereas patient rates reflect a medical care perspective that might, for example, focus on utilization histories or hospitalization careers. For a chronic illness such as asthma, events such as hospitalizations are expected to cluster in certain children. Patient rates estimated in this study are not true patient rates, because we did not have access to enrollment files and do not know how long individual patients were actually observed during the 5-year observation period. Some children entered the cohort during this period through birth and migration, whereas others left because they became too old to be a part of the study or left the area. Had only a few children accounted for the majority of admissions, it would have been essential to examine the degree of clustering in areas and calculate SEs accordingly. Instead, we found only minor clustering; multiple hospitalizations were not common. Differences in SEs after adjustment for clustering would have been negligible.

Although the threshold for admission throughout Rochester seems constant across socioeconomic areas, this observation may not be consistent in other communities. As previously noted, childhood hospitalization rates in Rochester for all conditions are low. Two communities with which Rochester has been compared, New Haven, and Boston, had asthma hospitalization rates that were twofold and fourfold greater. This may be explained partly by the influence of Rochester relative to these other urban areas, but differences in admission threshold also apparently contributed. Using the same primary measure of asthma severity as our study, Homer et al. found that mild asthma cases represented a lower proportion of all asthma admissions in Rochester than in either Boston or New Haven.

Potential Implications for Health Care Financing and Allocation of Health Care Resources

These data demonstrate that higher hospitalization rates cannot be assumed to identify opportunities for cost reduction. Standardized admission criteria will not necessarily reduce hospitalization. Instead, the dramatically higher hospitalization rate for inner-city children signals a need for intense efforts to reduce the racial and socioeconomic disparities in morbidity burden.

In developing policy to redress disparities, the potential of environmental and health service interventions should be considered. If genetic differences alone cannot explain disparities, environmental differences must be fundamental to their origin. Both health services and environmental interventions must be supported vigorously in efforts to reduce serious morbidity burden, particularly while their potential to reduce disparities remains incompletely assessed. Interventions directed at the environment offer the possibility of primary prevention, whereas primary care directed at asthma is focused on secondary prevention, principally on the improved use of medication.

The extent to which our observations for asthma are consistent under other conditions and in other communities warrants systematic attention. Knowledge of when higher rates signal excess utilization and when, instead, they mean greater needs should guide equitable national health policy.

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