The Ontario Asthma Regional Variation Study*

Emergency Department Visit Rates and the Relation to Hospitalization Rates

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Background: Hospitalization rates for asthma vary more than threefold across regions of Ontario. It is not known whether this variation is primarily due to regional differences in the rate of emergency department (ED) visits or hospital admissions.

Objective: To determine the variation in ED visit rates for asthma in Ontario, and the relation between ED visit rates and hospitalization rates.

Design, setting, and patients: We studied patients with an ED disposition diagnosis of asthma in a stratified sample of 16 hospitals (pediatric facilities, 13; adult facilities, 14) over a 1-year period. Pediatric patients were defined as those patients who were < 19 years of age.

Measurements: Direct age-standardized and sex-standardized ED visit and hospitalization rates, and the percentages of patients presenting to EDs and subsequently admitted to the hospital were calculated for each site. High/low ratios (ie, extremal quotients [EQ]), weighted coefficients of variation (CVs), and the systematic component of variation (SCV) were used to summarize the variation among hospitals.

Results: The total number of ED visits for asthma at participating sites was 12,518 (7,825 children and 4,693 adults). A total of 847 children (10.8%) and 322 adults (6.9%) were admitted to the hospital. Age-standardized and sex-standardized ED visit and hospitalization rates ranged from 8.7 to 25.2 per 1,000 population for children (EQ, 2.9; CV, 30.9%; SCV, 173; p < 0.001) and 1.7 to 10.1 per 1,000 population for adults (EQ, 5.9; CV, 52.9; SCV, 445; p < 0.001). The proportion of pediatric and adult ED visits resulting in admission to the hospital varied significantly by site (p < 0.001) and was inversely related to ED visit rates in children (p < 0.001) but not in adults. ED visit rates were related to hospitalization rates in children (p = 0.042) and adults (p < 0.0001), but only accounted for 4% and 27%, respectively, of the variation in hospitalization rates.

Conclusion: Hospitalization rates for asthma in Ontario are primarily influenced by the variation in the percentage of ED visitors admitted to the hospital rather than the ED visit rate.

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Key words: asthma; emergency department visits; epidemiology; hospitalization rates; regional variation

Abbreviations: CIHI = Canadian Institute for Health Information; CV = coefficient of variation; df = degrees of freedom; DHC = District Health Council; ED = emergency department; EQ = extremal quotient; FSA = forward sortation area; NACRS = National Ambulatory Care Reporting System; SCV = systematic component of variation

In the last 25 years, morbidity and mortality from asthma have increased worldwide, particularly among those < 35 years of age. Although Canadian mortality and hospitalization rates have stabilized, there is considerable variation in the hospitalization rates for asthma among the provinces and within regions of Ontario. Regional variation in hospitalization rates and mortality persist despite the publication of national and international consensus guidelines for asthma management. Age-adjusted and
sex-adjusted hospitalization rates per 1,000 population > 20 years of age in Ontario in 1992/1993 to 1994/1995 ranged from 0.65 in the Hamilton Wentworth District Health Council (DHC) to 2.10 in Renfrew County, a high/low rate ratio of 3.2. An even higher rate ratio (3.7) for age-adjusted and sex-adjusted hospitalization rates was documented during the same time period for children aged 0 to 19 years, which ranged from 2.2 per 1,000 population in the Hamilton-Wentworth DHC to 5.3 per 1,000 population in the Kent County DHC.

The identification of the determinants of variation in hospitalization rates would guide the development of strategic interventions to optimize asthma outcomes provincially and nationally. The risk factors for death from asthma are well-recognized. The risk factors for hospitalization that have been identified in several studies of academic asthma centers in the American health-care system are not necessarily generalizable to Canada or to community centers. Furthermore, none of the studies determined the extent to which the variation in risk factors accounted for the variation in the utilization of emergency department (ED) visits.

Hospitalization rates are the mathematical product of ED visit rates and the percentage of ED visitors who are admitted to the hospital. Therefore, the variation in hospitalization rates for asthma may be due to the variations in ED visit rates and/or hospital admission percentages. While the incidence and prevalence of asthma may vary somewhat among regions of Ontario, it is unlikely that these factors alone account for a greater than threefold variation in hospitalization rates in the province. If most of the variation in hospitalization rates is due to the variation in ED visit rates, and the percentage of patients who are admitted to the hospital has little influence, then efforts to optimize hospitalization rates should be directed toward the management of asthma in the community and access to care. If, on the other hand, hospital admission percentages are primarily influencing hospitalization rates, it is possible that ED practice patterns and access to inpatient services warrant attention. We hypothesized that ED visit rates for urgent asthma care in Ontario vary significantly among regions, but variation in ED management accounts for more of the variation in hospitalization rates.

This study was designed and conducted by the Ontario Respiratory Outcomes Research Network (1) to document the presence and magnitude of regional differences in ED visit rates and hospitalizations for asthma in Ontario and (2) to examine the relation between ED visit rates and hospitalization for asthma. Subsequent analyses are planned to identify factors associated with rate variations and hospital admission status, which account for regional differences.

**Materials and Methods**

Children (ie, persons < 20 years of age) and adults (ie, persons ≥ 20 years of age) with an ED disposition diagnosis of asthma in a stratified sample of 16 Ontario hospitals (13 pediatric facilities and 14 adult facilities) were studied over a 1-year period. Stratification was designed to include the following: academic hospitals (five) and community hospitals (nine [five urban, three rural]); a range of rates of hospitalization for asthma for adult and pediatric patients (based on 1992/1993 to 1994/1995 Canadian Institute of Health Information [CIHI] data); and hospitals from all seven Ontario Ministry of Health and Long-Term Care planning regions. The following sites (hospitals) were invited to participate: London (London Health Sciences Centre–South Street Campus and Children’s Hospital of Western Ontario); Hamilton (St. Joseph’s Hospital and Community Health Centre); Toronto (Toronto Western Hospital and Hospital for Sick Children); Kingston (Kingston General Hospital and Hotel Dieu Hospital); Ottawa (Ottawa Hospital Civic Campus); Sudbury (Sudbury Regional Hospital); Timmins (Timmins and District Hospital); Chatham (Chatham Hospital); St. Catharines (St. Catharines General Hospital); Brampton (William Oster Health Centre Brampton Memorial Hospital Campus); Oshawa (Lakeridge Health Oshawa); Picton (Quinte Health Care Prince Edward County Memorial Hospital); Belleville (Quinte Healthcare Belleville General Hospital); and Renfrew (Renfrew Victoria Hospital). All hospitals accepted the invitation to participate. Ethics approval was obtained from the Queen’s University Research Ethics Board and the ethics committee at each participating hospital.

Trained research assistants at each site reviewed the ED log books on a daily basis to identify all ED disposition diagnoses of asthma between March 1, 2001, and February 28, 2002. The inclusion criteria were as follows: (1) attendance for treatment of acute asthma; and (2) a disposition diagnosis from the ED of asthma, “reactive airway disease,” asthma with respiratory tract infection, asthma with bronchiolitis, or asthma with COPD. The exclusion criteria included the following: (1) patients with asthma

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Original Research
presenting for prescription refills only (ie, not for treatment of an acute exacerbation); (2) respiratory tract infection; (3) bronchiolitis or COPD without asthma; (4) visits from adults at pediatric sites or children at adult sites; and (5) patients without a valid Ontario postal code.

Birth date, visit date, gender, forward sortation area (FSA), which consists of the first three digits of the postal code of each patient’s residence and is necessary to determine whether the visit was by an Ontario resident (ie, contributed to the denominator for rate calculations), and disposition (ie, admitted or not admitted to the hospital) were collected on every visit for acute asthma care. Patients were contacted and invited to participate in a subsequent study involving a questionnaire and chart abstraction. One high-volume pediatric ED site randomly sampled and contacted one in seven patients who had made ED visits for evaluation in the subsequent study.

The CIHI developed a National Ambulatory Care Reporting System (NACRS) following the data collection phase of the current study. The NACRS database collected ED discharge diagnoses, resulting in an ED database analogous to the CIHI Discharge Abstract Database for hospitalizations. The data collected by CIHI on all asthma-related ED visits from fiscal 2002 to 2003 (ie, April to March) were tabulated using an analytical tool (InformRx; AdapCS Canada; Kingston, ON, Canada) to estimate the ED asthma market share of each site in every Ontario FSA. Asthma-related codes included the following International Classification of Diseases, 10th revision, codes: J45.0, J45.00; J45.01; J45.1; J45.10; J45.11; J45.8; J45.80; J45.81; J45.9; J45.90; J45.9; J44; and J44.8. The ED asthma catchment area of each site was then estimated by summing the product of the market share of the site and the 2001 census population across all Ontario FSAs. Calculations were performed separately for children and adults.

The rate calculations were based on all visits identified. Statistical tests were based on counting each patient only once. Patients with multiple visits who were admitted to the hospital following one or more of their ED visits, were counted as having been admitted to the hospital. The impact of repeat visits by the same patient on rates and hospital admission percentages was assessed by performing separate calculations using the first visit only. Age-specific and sex-specific ED visit rates and hospitalization rates were calculated for each site by dividing the number of ED visits and hospitalizations tabulated in each age and sex stratum by our estimate of the ED asthma catchment area of the site for that stratum. Ages were categorized into the following groups: 0 to 4 years; 5 to 9 years; 10 to 19 years; 20 to 29 years; 30 to 39 years; 40 to 49 years; 50 to 59 years; 60 to 69 years; and ≥ 70 years. Direct standardization was used to calculate all age-standardized and sex-standardized rates with the 2001 Ontario Census population as the reference. To assess for diagnostic misclassification, subgroup analyses were performed on children 5 to 19 years of age (regarding bronchiolitis) and adults 20 to 39 years of age (regarding COPD). Catchment areas for hospitalizations were assumed to be the same as the ED catchment areas, since all captured hospitalizations were admitted through the ED. The percentages of patients presenting to EDs who were subsequently admitted to the hospital were calculated for each site.

The variation of the standardized rates across hospitals was summarized by the high/low ratio (ie, extremal quotient [EQ]), the weighted coefficient of variation (CV), and systematic component of variation (SCV). The Mantel-Haenszel test, stratifying by age and gender, was used to assess the statistical significance of the rate variation among sites. The same procedure of stratifying by age and site was used to compare rates between genders for selected age groups. NACRS data from 2002 to 2003 were used to assess the stability of the magnitude of variation in rates and the generalizability of the findings. Specifically, the CV of the rates of our study sites based on NACRS data from 2002 to 2003 were compared to our data from 2001 to 2002 and all other Ontario hospitals using NACRS data from 2002 to 2003.

The percentage of ED visits resulting in hospital admissions was calculated separately for children and adults at each site. The between-site variation in hospital admission percentages was assessed by the standard χ² test. A χ² test for trend was used to test whether hospital admission percentages were related to ED visit rates. To measure the proportion of variation in the hospital admission percentage accounted for by the ED visit rates, and the proportion of variation in hospitalization rates accounted for by the ED visit rates, the ratio of the χ² test for trend and the standard χ² test was calculated. This generalized R² statistic is analogous to a regression R² statistic. All statistical analyses were conducted using a statistical software package (SAS, Version 8.2; SAS Institute; Cary, NC). All tests were two-sided, and a p value of < 0.05 was considered to be statistically significant.

RESULTS

ED Visits, ED Catchment, Crude ED Visit Rates, and Crude Hospital Admission Percentages

Figure 1 shows the number of ED visits identified (after weighting for the sampling rate of one in seven at one pediatric hospital), the number of ED visits excluded from analysis, the number of distinct cases, and the number of multiple ED visits. One adult hospital was excluded due to incomplete data capture, resulting in a final study sample of 15 hospitals (13 pediatric sites and 13 adult sites). Other reasons for exclusion included the following: the absence of a valid Ontario FSA; adult patients seen at pediatric sites; and pediatric patients seen at adults sites. More than 99.9% of adult and pediatric Ontario residents lived in FSAs with some asthma-related visits captured by NACRS, leaving < 0.1% that could not be allotted to the market share estimates. The participating study sites had an estimated combined catchment of 1,768,399 persons (574,304 children and 1,194,095 adults), which accounted for 15.5% of the Ontario population in 2001. The crude ED visit rates were 13.6 and 3.9 per 1,000 population, and the percentages of persons making ED visits who were admitted to the hospital were 10.8% and 6.9%, respectively, for children and adults.

ED Visit Rates and Hospital Admission Percentages by Age and Sex

Age-specific and sex-specific ED visit rates and the percentage of ED visits resulting in admissions to the hospital are illustrated in Figure 2. ED visit rates were significantly higher in boys than in girls < 10 years of age (p < 0.001), but were higher in women than men > 19 years of age (p < 0.001). The percentage of ED visits resulting in admissions was...
nearly identical between sexes up until age 39 years. The apparently higher percentage of women than men > 39 years of age who were admitted to the hospital approached statistical significance (p = 0.07).

Variation in ED Visit Rates by Site

ED visits, the estimated asthma-specific ED catchment, and age-standardized and sex-standardized asthma ED visit rates for children and adults at each study site are presented in Table 1. The variation in ED visit rates among sites for both children and adults was statistically significant (p < 0.001) [Table 1]. This variation persisted in the pediatric and adult subgroups of patients 5 to 19 and 20 to 39 years of age, respectively (p < 0.001) [Table 2].

Variation in Hospital Admission Percentages and Hospitalization Rates by Site

Age-standardized and sex-standardized hospital admission percentages and age-standardized and sex-standardized hospitalization rates for children and adults are outlined for the whole sample in Table 1 and for the age subgroups in Table 2. The percentage of ED visitors admitted to the hospital and hospitalization rates each varied significantly among sites for both children and adults in the whole sample (each site, p < 0.001) [Table 1] and in both subgroups (each, p < 0.001) [Table 2].

Impact of Repeat Visits on Rates and Hospital Admission Percentages

The magnitude and statistical significance of variation in ED visit rates and hospital admission percentages were not substantially affected by repeat visits by the same patient (data not shown).

Impact of Observation Units on Rates and Hospital Admission Percentages

Only 0.3% of ED visitors were discharged from an observation unit, and no site had > 4% of patients discharged from an observation unit.
**Table 1—ED Visits, Percentage of ED Visits Resulting in Admission, and Age-Standardized and Sex-Standardized ED Visit and Hospitalization Rates**

<table>
<thead>
<tr>
<th>Site</th>
<th>Admissions/ED Visits, No.</th>
<th>Admissions/ED Visits, Raw %</th>
<th>Estimated Catchment Population, No.</th>
<th>ED Visit Rate†</th>
<th>Hospitalization Rate†</th>
<th>Admissions/ED Visits, No.</th>
<th>Admissions/ED Visits, Raw %</th>
<th>Estimated Catchment Population, No.</th>
<th>ED Visit Rate†</th>
<th>Hospitalization Rate†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56/905</td>
<td>6.2</td>
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<td>23.2</td>
<td>1.45</td>
<td>23/721</td>
<td>3.2</td>
<td>119,357</td>
<td>6.1</td>
<td>0.19</td>
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<td>7,052</td>
<td>12.1</td>
<td>0.14</td>
<td>2/108</td>
<td>1.9</td>
<td>26,539</td>
<td>4.3</td>
<td>0.08</td>
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<td>3</td>
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<td>5.1</td>
<td>20,769</td>
<td>12.6</td>
<td>0.68</td>
<td>1/251</td>
<td>0.4</td>
<td>32,582</td>
<td>5.1</td>
<td>0.02</td>
</tr>
<tr>
<td>4</td>
<td>10/227</td>
<td>4.4</td>
<td>109,773</td>
<td>2</td>
<td>0.09</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4/129</td>
<td>3.1</td>
<td>5,507</td>
<td>23.8</td>
<td>0.81</td>
<td>5/167</td>
<td>3.0</td>
<td>18,577</td>
<td>9.7</td>
<td>0.22</td>
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<td></td>
<td></td>
<td></td>
<td>20/317</td>
<td>6.3</td>
<td>179,437</td>
<td>1.7</td>
<td>0.11</td>
</tr>
<tr>
<td>7</td>
<td>59/837</td>
<td>7.0</td>
<td>65,591</td>
<td>12.9</td>
<td>0.91</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>48/214</td>
<td>22.4</td>
<td>22,489</td>
<td>9.8</td>
<td>2.26</td>
<td>28/220</td>
<td>12.7</td>
<td>60,146</td>
<td>3.7</td>
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<tr>
<td>9</td>
<td>252/2,632</td>
<td>9.6</td>
<td>183,634</td>
<td>13.3</td>
<td>1.28</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>49/426</td>
<td>11.5</td>
<td>49,058</td>
<td>8.7</td>
<td>0.99</td>
<td>38/434</td>
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<td>124,402</td>
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<td>0.31</td>
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<tr>
<td>11</td>
<td>164/845</td>
<td>19.4</td>
<td>79,272</td>
<td>10.2</td>
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<td>191,670</td>
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<tr>
<td>12</td>
<td>58/363</td>
<td>16</td>
<td>37,988</td>
<td>9.8</td>
<td>1.60</td>
<td>43/416</td>
<td>10.3</td>
<td>113,177</td>
<td>3.8</td>
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</tr>
<tr>
<td>13</td>
<td>28/167</td>
<td>16.8</td>
<td>12,409</td>
<td>13.7</td>
<td>2.34</td>
<td>7/154</td>
<td>4.5</td>
<td>32,930</td>
<td>4.7</td>
<td>0.22</td>
</tr>
<tr>
<td>14</td>
<td>51/528</td>
<td>9.7</td>
<td>32,538</td>
<td>16.1</td>
<td>1.54</td>
<td>31/659</td>
<td>4.7</td>
<td>115,015</td>
<td>5.7</td>
<td>0.27</td>
</tr>
<tr>
<td>15</td>
<td>64/441</td>
<td>14.5</td>
<td>17,888</td>
<td>25</td>
<td>3.66</td>
<td>64/487</td>
<td>13.1</td>
<td>50,489</td>
<td>10.1</td>
<td>1.26</td>
</tr>
</tbody>
</table>

EQ = 18.7; Weighted CV, % = 43.2; SCV = 297; p value (df, 12)† < 0.001; 0.0001). These trends were positive and accounted for 4.3% of the total variation in hospitalization rates among sites for children, and 27.1% of the total variation for adults. After the exclusion of site 15 (the data point with the highest ED visit rate and hospitalization rate in Fig 4), the χ² test for trend was no longer significant for children (χ², 1.09; df, 1; p = 0.297; generalized R², 1.7%) or adults (χ², 1.36; df, 1; p = 0.244; generalized R², 2.1%).

**Relation Between ED Visit Rates and Hospital Admission Percentages**

The relations between ED visit rates and hospital admission percentages for children and adults are illustrated in Figure 3. The χ² test for trend was significant for children (χ², 24.6; degree of freedom [df], 1; p < 0.001) but not for adults (χ², 0.03; df, 1; p = 0.86). Sites with higher ED visit rates for children tended to admit a lower percentage of children to the hospital. The ED visit rate trend accounted for 18.5% (ie, the generalized R², 24.6/133.0) of the total variation in the percentage of patients admitted to the hospital among the hospitals for children, but accounted for only 0.03% for adults. After the exclusion of site 15 (the data point with the highest ED visit rate in Fig 3), the χ² test for trend was significant for children (χ², 56.6; df, 1; p < 0.0001) and adults (χ², 23.5; df, 1; p < 0.0001). The ED visit rate trend with site 15 excluded accounted for 45.0% and 28.6%, respectively, of the variation in the percentage of patients admitted to the hospital for children and adults.

**Relation Between ED Visit Rates and Hospitalization Rates**

The relation between ED visit rates and hospitalization rates for children and adults is illustrated in Figure 4. The χ² test for trend was significant for children (χ², 4.13; df, 1; p = 0.042) and adults (χ², 56.6; df, 1; p < 0.0001). These trends were positive and accounted for 4.3% of the total variation in hospitalization rates among sites for children, and 27.1% of the total variation for adults. After the exclusion of site 15 (the data point with the highest ED visit rate and hospitalization rate in Fig 4), the χ² test for trend was no longer significant for children (χ², 1.09; df, 1; p = 0.297; generalized R², 1.7%) or adults (χ², 1.36; df, 1; p = 0.244; generalized R², 2.1%).

**Interpretation**

This study demonstrated significant regional variation in age-standardized and sex-standardized ED visit rates for urgent asthma care in children and adults in a stratified sample of Ontario hospitals. ED visits were more common in male patients < 10 years of age and in female patients in all other age strata. The percentage of ED visitors who were admitted to the hospital for asthma also varied significantly by site and followed a bimodal age distribution, revealing a tendency to admit the very young and the elderly to the hospital. In addition, the percentage of ED visitors who were admitted to the hospital was inversely related to the ED visit rate in children but not in adults. The variation in hospital-
ization rates was primarily caused by the variation in hospital admission percentages rather than by the variation in ED visit rates in both age groups.

The sampling strategy for this study was intended to ensure that the findings are representative of all of Ontario. While site selection bias remains a theoretical limitation, the sampling frame used in this study generated sites with weighted CVs for ED visit rates that were comparable to those of all Ontario hospitals using the NACRS data. This suggests that the findings from our study may reasonably be generalized to Ontario, and that the analysis of the questionnaire and chart abstraction data for the determinants of variation in utilization rates is appropriate.

The accuracy of the disposition diagnosis of asthma in the ED is a potential limitation of the study.

Table 2—Subgroup Analysis of ED Visits, Percentage of ED Visits Resulting in Admission, and Age-Standardized and Sex-Standardized ED Visit and Hospitalization Rates in Children and Adults*

<table>
<thead>
<tr>
<th>Site</th>
<th>Admissions/ED Visits, No.</th>
<th>Admissions/ED Visits, Raw %</th>
<th>Estimated Catchment Population, No.</th>
<th>ED Visit Rate†</th>
<th>Hospitalization Rate†</th>
<th>Admissions/ED Visits, No.</th>
<th>Admissions/ED Visits, Raw %</th>
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<th>ED Visit Rate†</th>
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<td>1.5</td>
<td>44,175</td>
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<td>8</td>
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*Children aged 5–19 years; Adults aged 20–39 years. CV = coefficient of variation; EQ = extremal quotient; Inf = infinity; SCV = systematic component of variation.
†Per 1,000 population.
‡Mantel-Haenszel statistic stratified by age and sex.

Figure 3. The percentage of ED visits resulting in the admission of the patient to the hospital by ED visit rate with circle sizes proportional to the catchment population at the site for (left, A) children and (right, B) adults.
study. Diagnostic misclassification is a commonly cited potential explanation for increasing hospitalization rates and mortality rates from asthma in many countries. Bronchiolitis in young children and COPD in adults are often confused with asthma. However, the subgroup analyses in children (5 to 19 years of age) and adults (20 to 39 years of age) demonstrated comparable variations in ED visit rates and hospital admission percentages to the entire study sample. The variation in hospitalization rates in adults aged 20 to 39 years exceeded that of the entire adult sample. Therefore, if anything, diagnostic misclassification in adults may in fact have underestimated the magnitude of variation in hospitalization rates in adults overall. The magnitude and influence of regional differences in diagnostic labeling is unknown.

The best method for calculating hospital catchment populations remains controversial. A market-share approach is well-suited for the determination of health-care utilization when geographic boundaries for health services use overlap, as is the case in the larger centers included in our study. Hospital catchment areas based on all diseases are presumably different than ED catchment areas. Furthermore, ED catchment areas are likely condition-specific. Individuals with sudden severe symptoms (e.g., shortness of breath or chest pain) are more likely to visit the closest ED. Individuals with less alarming but emergent symptoms (e.g., a blocked dialysis catheter) may travel to an ED that is farther away but is better equipped to deal with the presenting complaint (e.g., a regional dialysis center). The recent availability of NACRS data enabled the application of a market-share methodology to calculate an asthma-specific ED catchment population for each hospital. This unique approach was used to obtain the most accurate denominator possible for rate calculations. The overestimation of ED catchment size will underestimate the calculated ED visit rate and vice versa. Participating hospitals from communities serviced by more than one ED are most susceptible to the overestimation or underestimation of catchment size, but this possibility is minimized by the market-share methodology. In the current study, there was no apparent systematic impact on estimated ED visit rates or estimates of variation in the sites served by multiple EDs. Since very few patients who were admitted to the hospital were transferred from other hospitals in this study, the ED catchment population was used to calculate hospitalization rates.

The most appropriate measure of variation is also somewhat controversial. The EQ is simple to understand and is commonly reported, which enables comparisons with published literature, but it is vulnerable to extreme values or outliers. The CV, which is the SD divided by the mean, is a more robust measure of variation than the EQ but may still overestimate variation when the rate is low or the population is small. Weighting the CV by the catchment population reduces this problem. The SCV accounts for a “random” variation in rates, provides an estimate of the “systematic” variation, and is stable across a range of rates and population sizes. It should be noted that these indexes assess the magnitude of variation; determining how much variation is “too much” is to a large extent subjective (i.e., it requires clinical judgment).

This study is the first to demonstrate regional variation in ED visit rates for asthma in children and adults in Ontario. The variation in ED visit rates in the current study (based on EQs) is comparable in magnitude to those of previous reports of variation in ED visits for children and adults in Quebec and in hospitalization rates in children in Ontario, but it

Figure 4. Hospitalization rate by ED visit rate with circle sizes proportional to the catchment population at the site for (left, A) children and (right, B) adults.
exceeds those of published reports of variation in hospitalization rates in adults in Ontario. The weighted CVs of ED visit rates in our study are even higher than the variation in hospitalization rates reported in the mid-1990s among the former DHCS in Ontario. 

Although there was good agreement between the estimates of variation in ED visit rates in our study compared to those for all Ontario EDs using NACRS data, our estimates of actual visit rates in study sites from 2001 to 2002 differed from the NACRS data taken from 2002 to 2003. The accuracy of the most responsible diagnosis is not yet known for NACRS data but is likely similar to that of the CIHI Discharge Abstract Database. The agreement of Canadian hospital discharge data with reabstraction studies has generally been >95% for demographics and ranged between 75% and 95% for respiratory diagnoses. However, ED visit rates may vary from year to year. The actual number of visits captured by NACRS in the following year is not critical for our study, but the relative share of each hospital in each the FSA is important as this is used to determine the catchment population. The relative share would probably only change significantly if there were major structural changes to the system such as the amalgamation of hospitals or the addition of new clinics. To our knowledge, no major changes occurred in our study sites during that time period, so any changes in market share from 2001 to 2002 and from 2002 to 2003 would likely have been minor. After the NACRS data collection period of 2002 to 2003, the restructuring of site 15 resulted in the closure of that ED. Since that site had the highest ED visit rates and hospitalization rates for children and adults in our study, we wonder whether their ED utilization and/or reporting to the CIHI may have begun to decrease during the NACRS data collection period, resulting in the underestimation of the catchment area and the overestimation of rates. NACRS data from 2002 to 2003 are therefore suitable for our market-share calculations, with the possible exception of those for site 15.

The proportion of individuals attending the ED and subsequently admitted to the hospital varied significantly by site, and to a much greater extent than did ED visit rates (Table 1). Many factors enter into a decision to discharge a patient from the hospital or to hospitalize a patient with an asthma exacerbation, even when they are of comparable severity. The presence of an observation unit was not a major factor in the current study. Professional uncertainty regarding the need for hospitalization likely contributed to this variation. Regression analyses may elucidate the role of and interactions between patient characteristics, other site characteristics, and practice patterns.

Stratification by age revealed a higher hospital admission percentage in young children and older adults. The tendency toward higher ED visit rates in women compared to men did not reach statistical significance. These age and sex differences in ED visit rates and hospital admission percentages are in keeping with Canadian asthma hospitalization data. It is not known whether these findings reflect differences in asthma prevalence or severity, the health care-seeking behavior of patients, and/or management practices.

There was an inverse association between the ED visit rate and the percentage of ED visits by children resulting in admission to the hospital, but this did not occur in adults unless the possible influential site (site 15) is excluded from analysis. This suggests that a lower threshold of asthma severity in children (and possibly adults) prompts an ED visit at some sites, which may reflect a lack of other options for care in the community (e.g., differences in access to care across regions results in patients with milder disease presenting more commonly to EDs in communities without after-hours walk-in clinics). An alternative hypothesis to explain the inverse association is a lower hospital admission threshold at sites that see asthma patients less frequently, which could be regarded as appropriate caution of physicians providing care at those centers.

Hospitalization rates, ED visit rates, and the percentage of ED visitors who were admitted to the hospital all varied significantly among sites for children and adults in this study. The variation in ED visit rates accounted for <5% of the variation in hospitalization rates in children, and for not >27% of the variation in hospitalization rates in adults. The variation in hospitalization rates must be largely, if not entirely, related to the variation in its other determinant, the percentage of ED visitors admitted to the hospital.

These study findings generate a number of hypotheses, some of which will be tested by subsequent regression analyses of the questionnaire and chart abstraction data. The extent to which asthma prevalence varies among regions in the province and contributes to the variation in ED visit rates will remain speculative until a valid surveillance system is in place. We suspect that the severity of an asthma exacerbation that prompts emergency care and how well the asthma is managed prior to the ED visit strongly influence ED visit rates. ED visit thresholds are likely affected by access (or lack thereof) to alternative asthma care services in the community. Since hospitalization rates were largely unrelated to ED visit rates, we hypothesize that a variation in the
severity of asthma patients presenting to EDs, the care given in the ED, and hospital admission thresholds largely account for the variation in hospitalization rates.

In summary, there were significant differences in age-standardized and sex-standardized ED visit rates for asthma in children and adults among Ontario hospitals. ED visit rates were highest in young children, particularly boys. The percentage of ED visitors who were admitted to the hospital varied by age. The ED visit rate was inversely related to the percentage of ED visits by children admitted to the hospital, but accounted for only a small proportion of its variation. Furthermore, the variation in ED visit rates had little if any influence on hospitalization rates in children or adults. Hospitalization rates were primarily influenced by the variation in hospital admission percentages. ED management and access to asthma care should be examined to determine their consistency with published guidelines and to identify areas of the health-care system that may be improved to optimize asthma care and patient outcomes.

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