

# Using Billing Data to Describe Patterns in Asthma-Related Emergency Department Visits in Children

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## ABSTRACT

**OBJECTIVES.** To describe the development and evaluation of a pilot emergency department (ED)-based asthma surveillance system for childhood asthma visits based on billing data and to illustrate how the data can be used to document trends and patterns in ED visits for asthma in children.

**METHODS.** During 2001 and 2002, aggregate reports based on ED billing data from 3 hospitals in western Michigan were obtained from a single physician billing company. Data were tabulated and graphed to show trends in the monthly number of ED visits for asthma in children. Comparisons were made by age, gender, and site. We evaluated the system by using established guidelines.

**RESULTS.** The data illustrated strong seasonal trends, as well as marked differences in ED use according to age and gender. The total numbers of asthma ED visits were remarkably similar between the 2 years evaluated; however, the timing and duration of the seasonal peaks differed. Our evaluation of the system found that it met many of the characteristics that define successful surveillance systems, including simplicity, flexibility, acceptability, sensitivity and positive predictive value, timeliness, and stability. However, the surveillance system's representativeness was limited by the inability to calculate valid population-based ED-visit rates. Despite this limitation, the data provided useful information by documenting the burden and demographic profile of children who use the ED for asthma care and in identifying seasonal and time-related trends.

**CONCLUSIONS.** We were able to successfully implement a pilot ED-based surveillance system for childhood asthma visits by using billing data. This system promotes the understanding of the burden of asthma among children visiting the ED. The development of an ED-based surveillance system for childhood asthma visits using billing data is recommended, particularly when there is a desire to understand the characteristics of children with asthma who use the ED and/or a need to understand the impact of local asthma quality-improvement programs.

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### Key Words

pediatric asthma, emergency department utilization, public health surveillance, billing data

### Abbreviations

ED—emergency department  
QI—quality improvement  
ICD-9—*International Classification of Diseases, 9th Edition*  
CDC—Centers for Disease Control and Prevention

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**A**STHMA IS ONE of the most common reasons for presentation to emergency departments (EDs), and this chronic disease places a heavy but potentially preventable burden on the US health care system.<sup>1-3</sup> Children  $\leq 14$  years of age make  $\sim 600\,000$  ED visits for asthma every year in the United States, and the number of ED visits increased by 14% during the 1990s.<sup>1</sup> Between 10% and 30% of ED visits for asthma are repeat visits, and frequent ED use is associated with greater asthma severity and/or poor management, as well as poverty, ethnicity, and urban residence.<sup>4-7</sup> The current high level of interest concerning asthma stems from several features including the increase in asthma prevalence and mortality observed over recent decades,<sup>8,9</sup> the large costs involved,<sup>10</sup> the disproportionate effect on minority populations,<sup>11</sup> the concern about possible environmental causes, and the belief that the application of current clinical guidelines should result in better asthma control.<sup>12</sup>

Public health surveillance is defined as the systematic collection, analysis, interpretation, and dissemination of data for use in prioritizing, planning, implementing, and evaluating public health programs, activities, and practice.<sup>13</sup> Surveillance for chronic diseases such as asthma requires access to multiple data sources including vital statistics, registries, health surveys, and administrative data such as billing information.<sup>14</sup> Similar to many states, Michigan has access to only a limited array of statewide data sources (including mortality, hospitalization, Medicaid claims, and Behavioral Risk Factor Survey data) that can be used for asthma surveillance. The lack of a comprehensive asthma surveillance system, either at the state or federal level, has been identified as a major shortfall in the current public health approach to asthma.<sup>1,15-17</sup> Asthma-related ED visits represent a large portion of asthma morbidity for which data are not widely available at the state level; currently, only  $\sim 20$  states have access to ED encounter data.<sup>18</sup> Surveillance of ED pediatric asthma-related visits generated from already existing data sources such as billing data<sup>19</sup> can be used to characterize patients with asthma in terms of their demographic profile, date and time of presentation, geographic location (ie, zip code of residence), hospital admission rates, repeat visit rates, payer source (ie, insurance status), and direct medical costs. Asthma-related ED surveillance data have several potential uses and applications including the ability to characterize ED-utilization patterns, monitor outcomes of ED visits (ie, hospitalizations and repeat ED visits), identify subpopulations of children with a high asthma burden, quantify the role of ambient air quality and other environmental risk factors on asthma exacerbations, and evaluate the impact of hospital or community-based quality-improvement (QI) programs designed to improve asthma care.

The objectives of this study are to (1) describe the

development of a pilot ED-based asthma surveillance system for childhood asthma visits based on billing data, (2) illustrate how billing data can be used to document trends and patterns in asthma ED visits by children, (3) evaluate the characteristics of this surveillance system using published criteria<sup>20</sup> (ie, feasibility, usefulness, accuracy, representativeness, and acceptability), and (4) make recommendations with respect to using billing data as the basis for an ED-based surveillance system for children.

## METHODS

The Grand Rapids Asthma Study was an ED-based surveillance and intervention project for children and adults who visited the ED for treatment of acute asthma exacerbation. Located in Kent County in western Michigan, Grand Rapids is the state's second largest city, with a population of  $\sim 575\,000$ . Three EDs were selected from the Grand Rapids area to be representative of urban, suburban, and rural hospital settings. The urban and suburban sites represent the 2 largest hospitals (of the 4 total) in Grand Rapids. The rural site was located  $\sim 35$  miles north of Grand Rapids in a small town that serves Newaygo county, which has a population of  $\sim 50\,000$ .

All 3 sites were served by the same ED-based physician billing company, which provided billing data on all asthma visits using a commercially available computerized billing system (Plus Medic Software; Misys Healthcare Systems, Raleigh, NC). For every ED visit, the system automatically recorded the name, address, date of birth, gender, Social Security number, medical chart number, primary diagnosis code (based on the *International Classification of Diseases, 9th Edition* [ICD-9]), up to 5 secondary diagnostic codes, up to 6 Current Procedural Terminology (CPT) or procedure codes, details of insurance coverage, hospital admission, previous ED visits in the last 12 months, and previous ED visits in the same calendar month for the same primary diagnosis (ie, repeat visit). On a quarterly basis between October 2000 and September 2003, the billing company prepared de-identified aggregate reports in spreadsheet format (Microsoft Excel; Microsoft Corp, Redmond, WA). The exact content and format of the reports were determined by the investigators and the billing company's technical staff at the onset of the project. The reports included the monthly counts of all visits with a primary ED discharge diagnosis of asthma (ICD-9 code: 493) arranged according to age ( $< 2$ , 2-5, 6-11, 12-17, and  $\geq 18$  years) and gender. Other data included the number of hospital admissions per month (reported separately for children [aged  $\leq 17$  years] and adults [aged  $\geq 18$  years]), the number of repeat ED visits for asthma by calendar month, and the day of the week of the visit (for these latter 2 measures, data for children and adults were combined).

The quarterly reports were aggregated to produce

annual totals for each of the 3 sites and the overall total. Only data for the complete calendar years 2001 and 2002 were included in this report. The data were tabulated and graphed to show trends over time in the number and proportion of ED asthma visits among children each month. Comparisons then were made by age (ie, <2, 2–5, 6–11, and 12–17 years), gender, and site. Because of small numbers, some categories were collapsed to obtain more stable trends. Differences in the proportion of asthma visits by age and gender by site were explored by using  $\chi^2$  analyses. We chose not to calculate population-based rates of ED use (using census data as denominators), because the available billing data did not represent a complete census of all ED visits in the Grand Rapids area, and thus the rates would be difficult to interpret. Using the total number of ED visits as the denominator, we calculated the proportion of ED visits that resulted in hospitalization (by month and for the whole year), and the proportion of ED visits that represented a repeat visit for asthma within the same calendar month.

We evaluated this ED-based asthma surveillance system by using the Centers for Disease Control and Prevention (CDC) Guidelines for Evaluating Public Health Surveillance Systems.<sup>20</sup> The following 10 characteristics were considered.

1. Usefulness: whether the surveillance system contributes to the prevention and control of asthma, including an improved understanding of the public health implications of asthma.
2. Simplicity: the system's structure and ease of operation.

3. Flexibility: the adaptability of the system to changing information needs with little additional time, personnel, or allocated funds.
4. Data quality: the completeness and validity of the data.
5. Acceptability: the willingness of persons and organizations to participate in the surveillance system.
6. Sensitivity: either the proportion of ED asthma cases detected (ie, a measure of the system's completeness) or the ability of the system to monitor changes in the number of cases over time.
7. Positive predictive value: the proportion of reported cases that actually have the disease or health event under surveillance.
8. Representativeness: the system's ability to describe the occurrence of a disease or health event accurately over time and its distribution in the population by place and person.
9. Timeliness: the time taken to undertake the key steps in the surveillance system.
10. Stability: the surveillance system's ability to collect, manage, and provide data properly without failure and to be operational when needed.

## RESULTS

Table 1 shows the total number of visits for asthma among children treated at the 3 EDs during the 2-year period. The numbers were remarkably consistent across the 2 years, with the urban site accounting for just over three quarters of the total visits. Similarly, the age and

**TABLE 1** Number of ED Visits for Asthma in Children According to Age and Gender for 3 EDs: Grand Rapids Asthma Study, 2001 and 2002

	Urban, <i>n</i> (%)	Suburban, <i>n</i> (%)	Rural, <i>n</i> (%)	Total, <i>n</i> (%)
2001				
Age, y				
<2	137 (19.5)	15 (13.0)	11 (14.3)	163 (18.2)
2–5	229 (32.5)	37 (32.2)	24 (31.2)	290 (32.4)
6–11	215 (30.5)	33 (28.7)	23 (29.9)	271 (30.2)
12–17	123 (17.5)	30 (26.1)	19 (24.7)	172 (19.2)
Gender				
Female	263 (37.4)	48 (41.7)	33 (42.9)	344 (38.4)
Male	441 (62.6)	67 (58.3)	44 (57.1)	552 (61.6)
Total	704 (100.0)	115 (100.0)	77 (100.0)	896 (100.0)
2002				
Age, y				
<2	109 (15.9)	13 (10.7)	6 (7.6)	128 (14.4)
2–5	249 (36.4)	43 (35.2)	25 (31.6)	317 (35.8)
6–11	201 (29.3)	41 (33.6)	27 (34.2)	269 (30.4)
12–17	126 (18.4)	25 (20.5)	21 (26.6)	172 (19.4)
Gender				
Female	268 (39.1)	38 (31.1)	27 (34.2)	333 (37.6)
Male	417 (60.9)	84 (68.9)	52 (65.8)	553 (62.4)
Total	685 (100.0)	122 (100.0)	79 (100.0)	886 (100.0)

gender distributions were consistent across the 2 years; the majority of children were between 2 and 11 years of age, and just over 60% were male. There were no statistically significant differences in the age or gender distributions among the 3 sites.

The monthly proportion of ED visits for asthma among children in 2001 and 2002 is shown according to age (Fig 1), gender (Fig 2), and site (Fig 3). The trend lines show the expected seasonal variability in asthma visits with high peaks in the winter (January to March) and fall (September to November) and low rates in the summer (June to August). Figures 1 and 2 illustrate that there were few differences in the seasonal variation according to age (defined as  $\leq 5$  or 6–17 years) or gender across the 2 years. However, the graphs do show variation in the timing and extent of the winter and fall peaks; in 2002 the winter peak occurred a little later and

extended into May, whereas the fall increase was more pronounced and had an obvious peak in October. The overall seasonal pattern is again repeated when the data are examined according to site (Fig 3). Although there is some evidence of a different pattern for the rural site, with a larger peak in the summer months, the relatively small number of visits at this site precludes drawing any firm conclusions.

Data on the proportion of ED visits that resulted in hospitalization were reported for children of all ages (ie, 0–17 years) and for adults (ie,  $\geq 18$  years). In 2001, 11% of ED visits for asthma in children resulted in hospital admission, compared with 15% in adults. In 2002 the difference was even larger, with 10% of children being admitted, compared with 18% of adults. Figure 4 shows the monthly pattern in the proportion of ED visits for asthma that resulted in a hospital admission for children

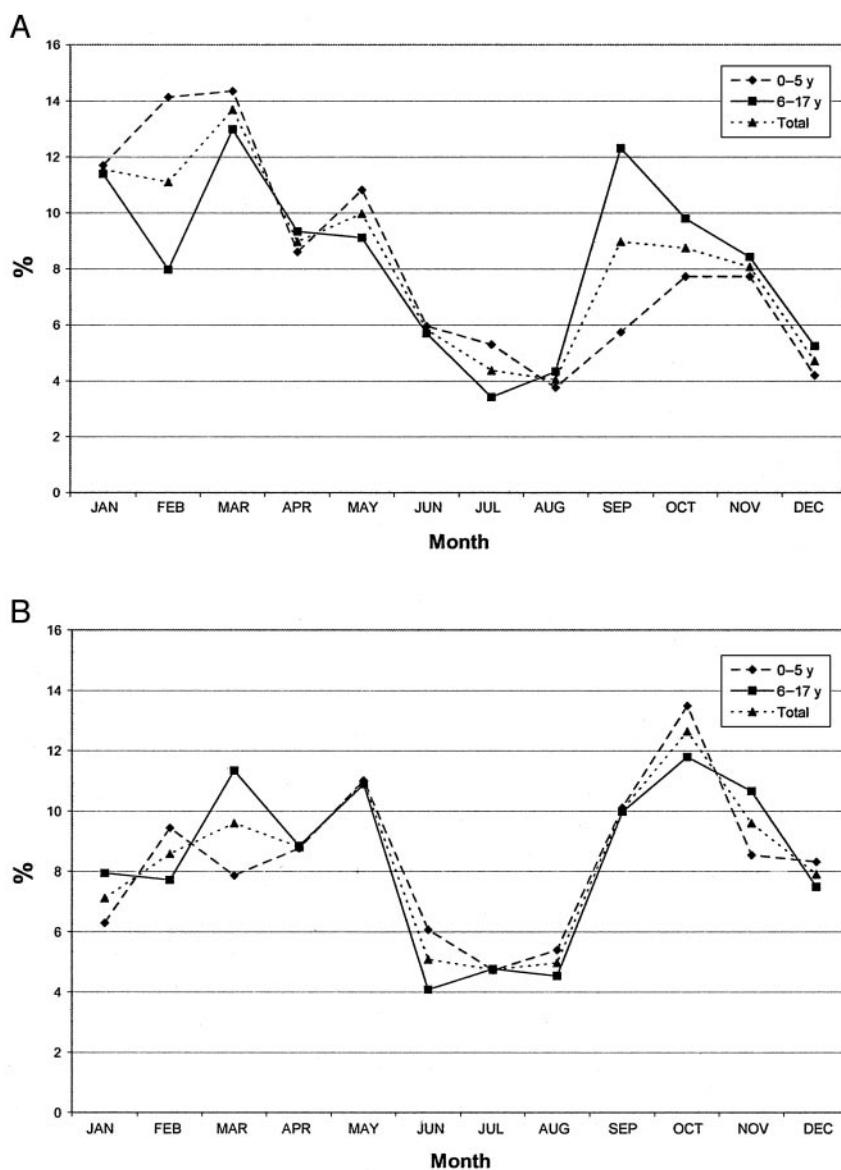
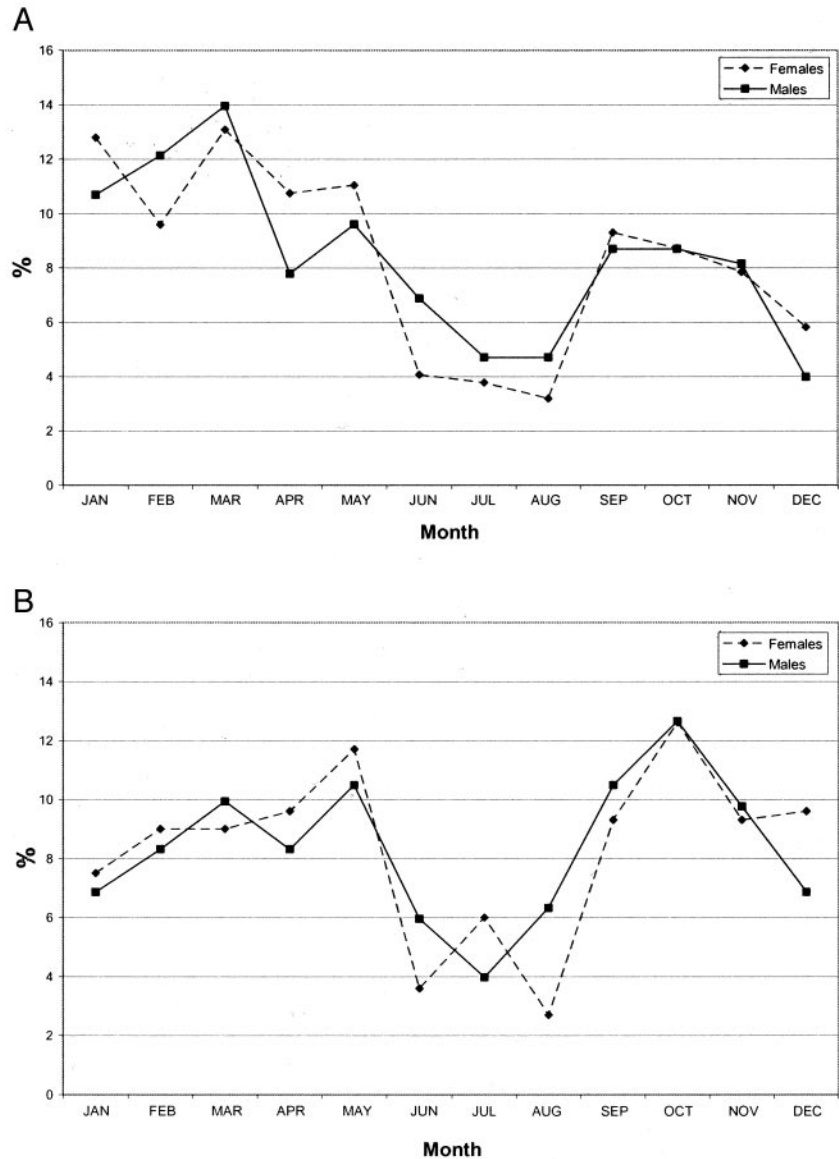


FIGURE 1  
Proportion of ED visits for asthma in children according to month and age: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).



**FIGURE 2** Proportion of ED visits for asthma in children according to month and gender: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).

and adults. Overall, the seasonal variability in admissions was less pronounced than that seen for asthma-related ED visits, although admissions were still more common in the winter months (January to March) and less common in the summer (ie, June to August).

Repeat visits, defined as another ED visit for asthma within the same calendar month as the first visit, were reported only for all age groups combined (ie, children and adults). Overall, 5.1% and 3.4% of asthma visits were repeat visits in 2001 and 2002, respectively. Figure 5 shows the monthly pattern in the proportion of ED visits that were repeat visits. In 2001 there were more repeat visits in the late spring and in the fall, which is typical of the overall pattern of ED visits. However, this trend was not seen for 2002, in which the proportion of repeat visits was much more erratic. Finally, the trends in asthma visits by day of the week (for children and

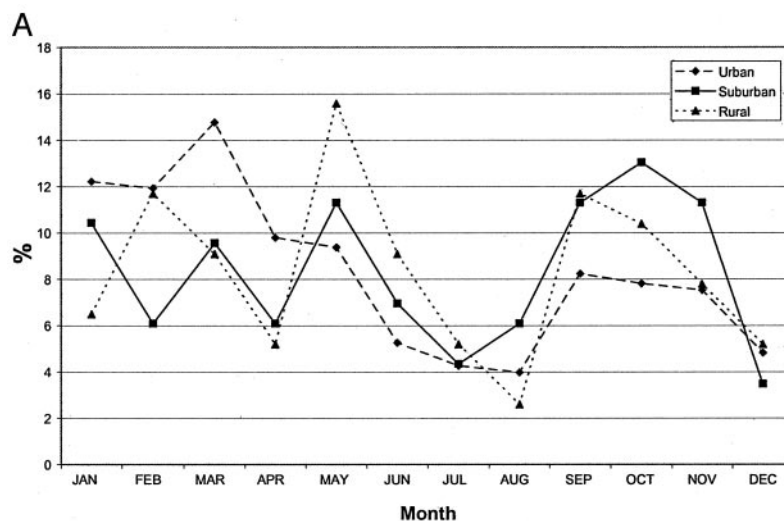
adults combined), shown in Fig 6, clearly illustrates the greater proportion of visits that occurred on Sundays and Mondays. This pattern was similar across all 3 ED sites, although the rural site again showed more variability because of small numbers.

**Surveillance-System Evaluation**

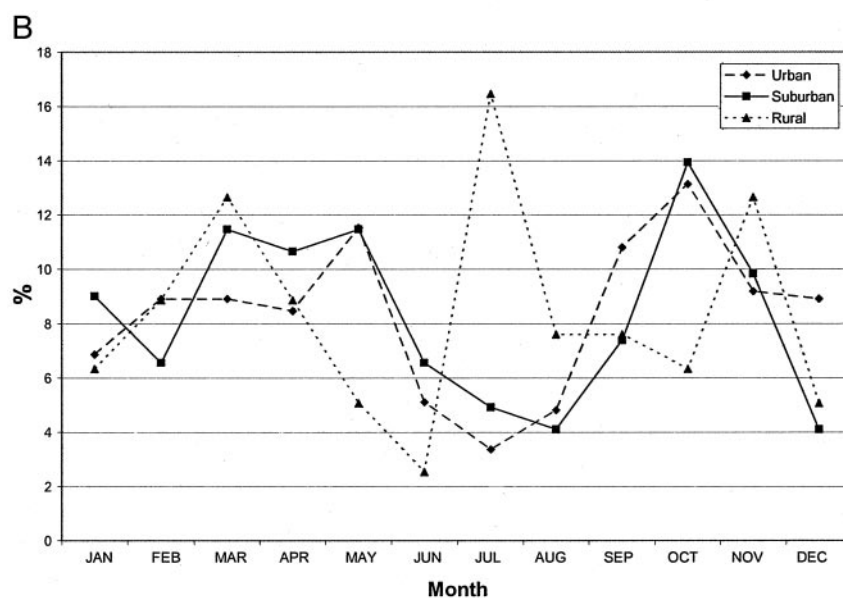
A brief outline of the evaluation of the ED asthma surveillance system based on the CDC guidelines<sup>20</sup> is presented below.

1. Usefulness—Because of the inability to calculate valid population-based rates, the system was unable to accurately define the magnitude of asthma-related morbidity on a population basis. However, because the system can clearly detect important seasonal and time-related trends in asthma visits within





**FIGURE 3**  
Proportion of ED visits for asthma in children according to month and site: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).

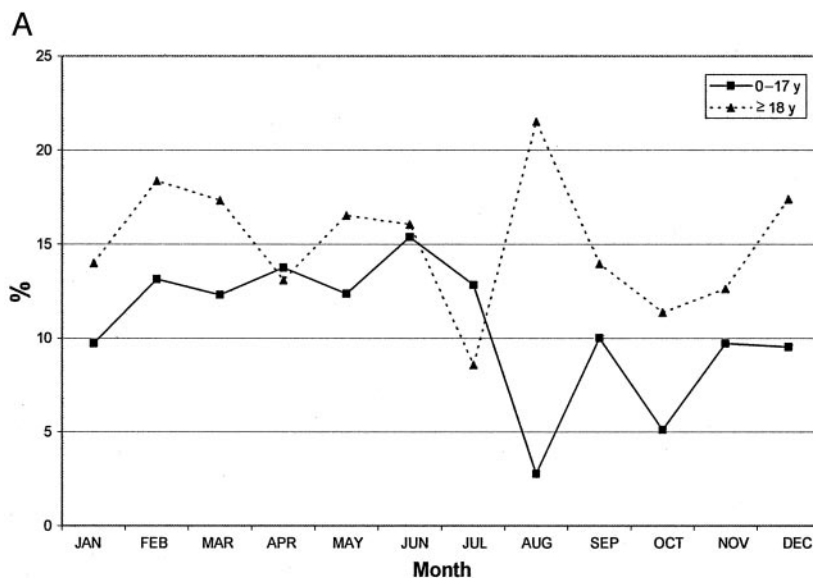


an individual hospital, it would be useful to assess local prevention and control programs, particularly those related to ED- or community-based QI initiatives.

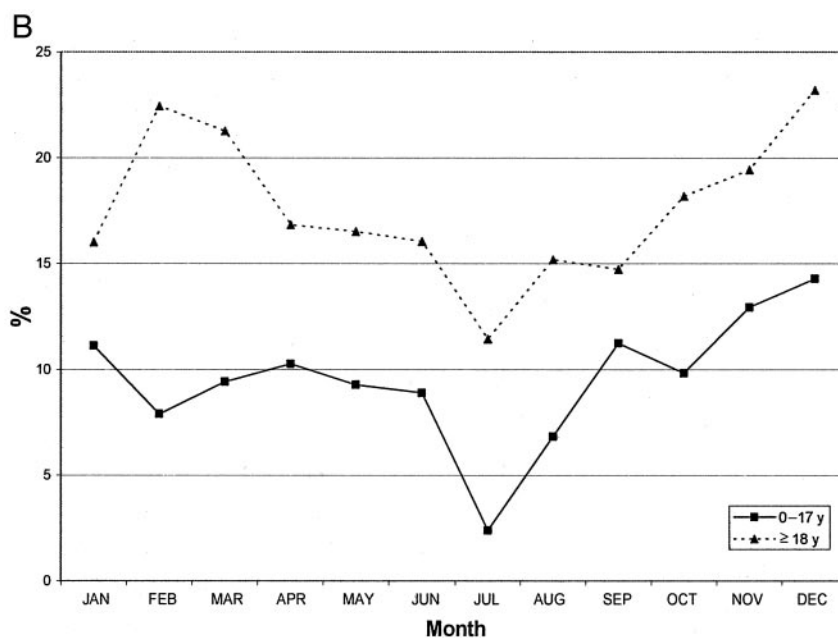
2. **Simplicity**—The current system is simple and easy to operate. The data are generated automatically by the billing company, and the quarterly reports are prepared and transmitted to the study investigators with relative ease. Once the format for the presentation of the data was defined, the data processing and analysis work was also relatively simple. The fact that the system relies on only 1 billing company, rather than several hospitals, also simplifies the system and increases its efficiency.
3. **Flexibility**—The system is flexible in terms of the ability of the billing company to change the content and format of the aggregate reports; however, the

exact content of the reports is limited to the data included in the billing system.

4. **Data quality**—We conducted a separate validity study that found that the billing data had sufficient completeness and validity for surveillance purposes as measured by the system's sensitivity, specificity, and positive predictive value.<sup>21</sup>
5. **Acceptability**—Our current system seems to be highly acceptable to the parties involved. Generation of the aggregate reports by the billing company occurred with ease and in a cooperative environment. However, our experience in trying to expand such a system to include other hospitals does suggest problems with acceptability. Other area hospitals were approached, but not all were willing to provide aggregate billing data, citing concerns over the dif-



**FIGURE 4**  
Proportion of ED visits resulting in a hospital admission in children and adults: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).

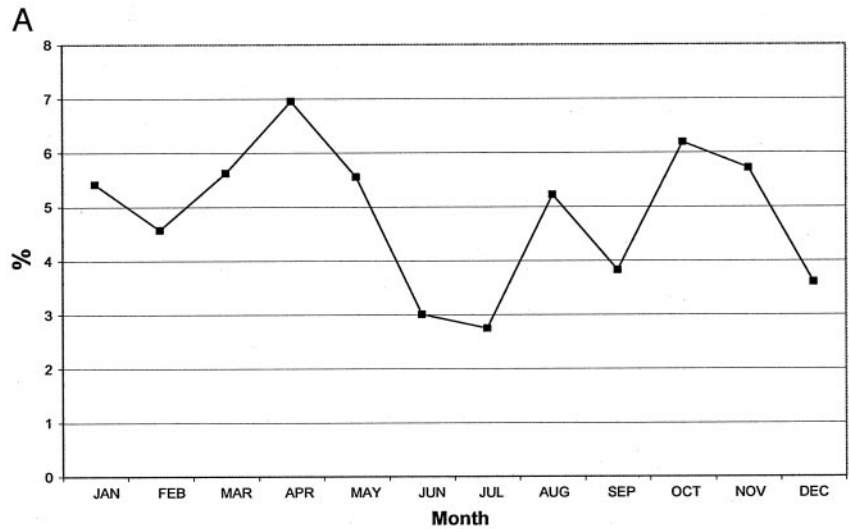


ficulty and cost of data reporting as well as patient privacy and confidentiality.

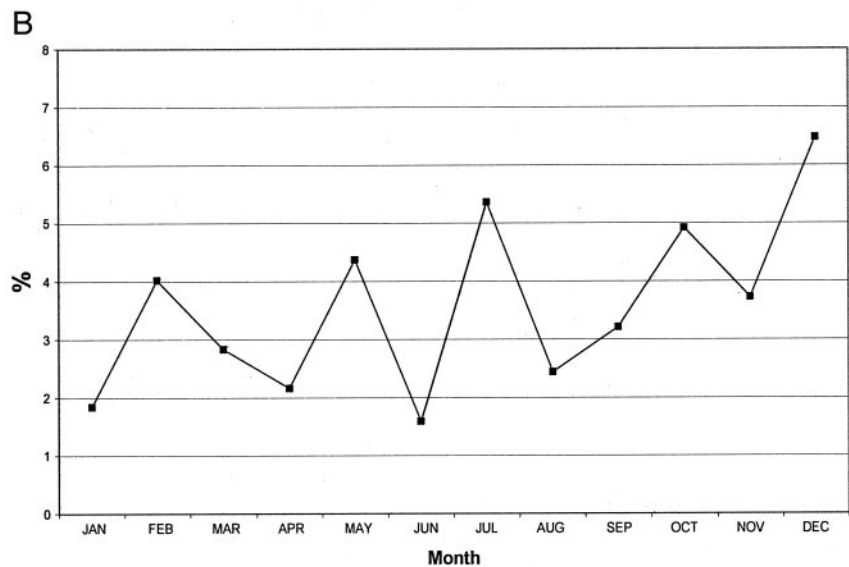
6. Sensitivity—The sensitivity of a surveillance system (ie, the proportion of ED asthma cases detected) was addressed in a separate validation study that found that a high proportion (86.4%) of ED asthma cases were identified by the billing data.<sup>21</sup> In terms of the system's ability to monitor changes over time, the presentation of the trend data illustrates that the system is very capable of monitoring changes in the number of ED asthma visits over time.
7. Positive predictive value—Data generated from the validation study demonstrated that a high proportion (98%) of asthma case-patients identified by the

billing data had indeed visited the ED for asthma treatment.<sup>21</sup>

8. Representativeness—Because this system used data from only 3 hospitals, it is not able to depict the distribution of ED use for asthma care accurately in the Grand Rapids population as a whole. However, the system is clearly representative of the ED population at each of these 3 hospitals and as such is able to illustrate the occurrence of asthma visits over time, thus addressing one of the key characteristics of a representative system. With the billing data, we were able to document several general asthma trends (eg, the preponderance of boys and younger children [2–11 years of age] and the clear



**FIGURE 5**  
Proportion of ED visits resulting in a repeat visit for asthma, children and adults combined: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).



seasonality pattern). These findings are similar to those reported previously, suggesting that the data have high face validity. If a surveillance system could be developed by using billing data from all the hospitals in a defined region, or from that state as a whole, we would expect the data to have excellent representation and generalizability.

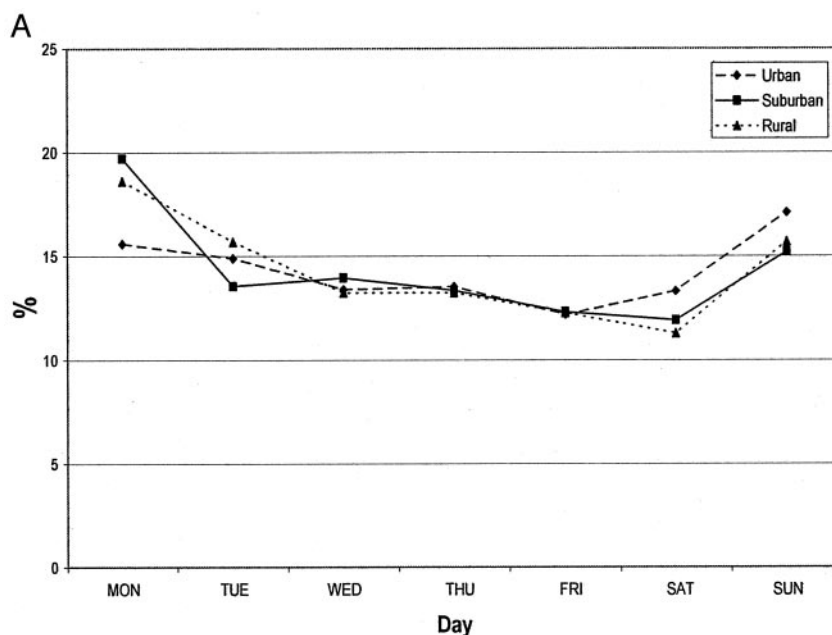
9. **Timeliness**—Given the nature of asthma, timeliness is not a critical feature of this surveillance system, so the quarterly reports are more than sufficient for our purposes. The hospitals process and forward their data to the billing company on a monthly basis, usually 1 to 2 weeks after the end of each month. Overall, the timeliness of this billing data is much better than that of most other administrative data sources, which often require several months for the data to become available.

10. **Stability**—Stability of the ED asthma surveillance system refers to the components of reliability (ie, the ability to be operational when needed). The current system demonstrates good stability in that it is able to collect, manage, and provide data when needed without a high likelihood of failure. However, this is in large part because of the small number of people involved in the system and the interest of the billing company in providing the data. The stability of a more comprehensive system involving multiple hospitals would be questionable, especially without clear safeguards to ensure that accurate and complete data are reported in a timely manner.

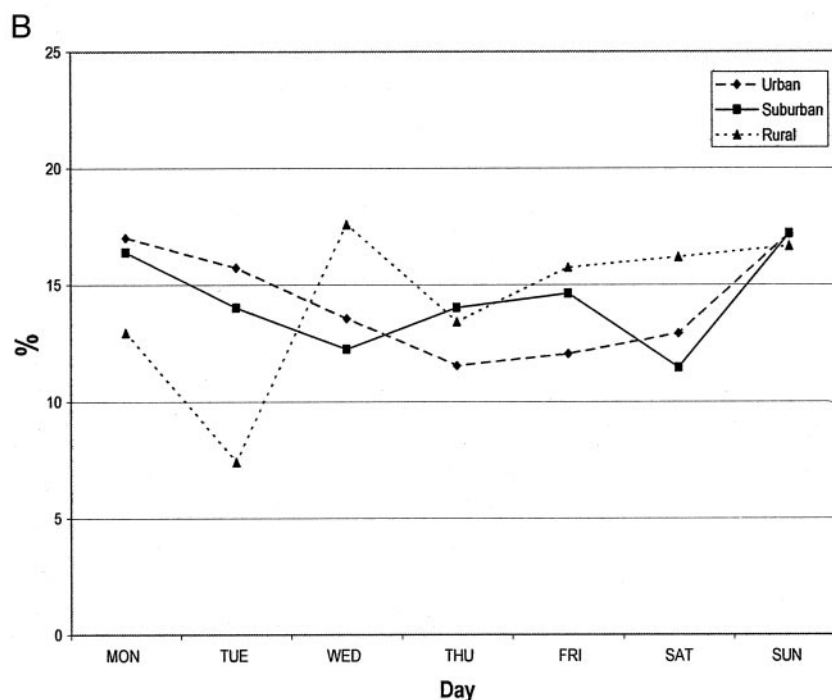
## DISCUSSION

Our analysis of data from this pilot asthma surveillance system found that the descriptive epidemiology of child-





**FIGURE 6**  
Proportion of ED asthma visits according to day of the week and site, children and adults combined: Grand Rapids Asthma Study, 2001 (A) and 2002 (B).



hood ED asthma visits at these 3 sites was similar to that reported previously. Among children presenting to the 3 EDs for asthma care, there was a preponderance of boys and children aged 2 to 11 years. Our surveillance system also noted strong seasonal trends in the number of ED visits, in line with what has been reported previously.<sup>19,22-24</sup> Although the seasonal trends showed little variation according to age, gender, or ED site, the exact timing and extent of the seasonal peaks were different between the 2 years. Year-to-year variation in the timing

and duration of peaks in asthma ED visits has also been reported previously.<sup>24</sup> We also found evidence of seasonal trends in the rate of hospitalization accompanying ED visits for asthma. The increased tendency for ED patients with asthma to be hospitalized in the winter months may indicate an increase in the severity of asthma per se or, perhaps more likely, an increase in other comorbid conditions (such as infectious respiratory disease) during these months.

The public health burden of asthma in children is

clearly sufficient to justify the development of comprehensive asthma surveillance systems, yet few if any examples of such systems currently exist in the United States.<sup>15-17</sup> The high frequency of children having asthma-related ED visits necessitates the inclusion of ED billing data in any comprehensive surveillance system. However, as mentioned previously, only a limited number of states have access to ED billing data, let alone the capacity to integrate that data into a true state-level asthma surveillance system.<sup>18</sup> The key advantage of using ED billing data is that because such data are generated automatically for every medical encounter, the development of a surveillance system based on these data should be relatively inexpensive. Although the number of data elements included in billing systems is limited, it is adequate for surveillance purposes, as illustrated by this and other analyses.<sup>19</sup> Billing data have many potential uses including the ability to characterize differences in asthma-related ED visits among demographic subgroups (ie, according to age, gender, and race) and seasonality, as well as to monitor hospital admissions and repeat ED visits. Billing data may also be used to generate hypotheses that lead to more in-depth epidemiologically and clinically based studies, such as identifying and targeting subgroups with high ED utilization.<sup>25</sup> Finally, billing data may be useful in the assessment of local hospital- or community-based QI initiatives designed to improve asthma care and control.<sup>26</sup>

A surveillance system based on billing data has several potential limitations. The documentation of race and ethnicity by hospitals is frequently incomplete,<sup>27</sup> so these data are often lacking from billing data (as was the case in our system). Other data such as insurance status may not be presented in a form that makes it easy to summarize. Also, unless the ED data can be linked by using individual identifiers, it may not be possible to identify repeat ED visits. Analysis of zip code-level data requires the calculation of population-based rates, and so the billing data need to include all of the relevant hospitals in a given region. Finally, billing data cannot capture other critical information such as underlying disease severity, access to primary care services, and current treatment and disease control. Such detailed patient-specific information would need to be collected either through patient interviews or detailed medical chart audits, ideally as part of an ongoing QI initiative.<sup>28</sup>

Although concern has been raised about the ability of ED billing data to identify asthma visits accurately,<sup>19,22</sup> there is little previous research on this issue.<sup>29</sup> Our validity work illustrated a high degree of concordance between the diagnosis reported by the physician in the ED record and the billing data, resulting in the billing data having high sensitivity and positive predictive value to identify asthma visits.<sup>21</sup>

The guidelines produced by the CDC for the evaluation of public health surveillance systems provided a

thorough and insightful look into the manner in which our pilot surveillance system either excelled or failed to perform. After evaluating our system, we found that it included many of the characteristics that define successful surveillance systems, including simplicity, flexibility, acceptability, sensitivity, positive predictive value, timeliness, and stability. Overall, the successful implementation of this pilot system was largely a result of the fact that it involved a single entity (the physician billing company) and that we had a strong physician champion who facilitated access to the data. As described earlier, our inability to calculate valid population-based ED-visit rates understandably limited the system's representativeness. However, this should not be regarded as a fatal flaw of this system, because other useful information (including describing the burden and demographic profile of children using the ED for asthma care, identifying seasonal and other time-related trends, and monitoring hospitalizations and repeat ED visits) can all be generated from these data. We believe that time-related trends generated from these data are representative, because we found no evidence of any significant changes to the underlying population demographics or the asthma referral patterns to these EDs during the 2-year study period. Population-based rates are useful when there is a need to compare ED-visit rates by demographic subgroups (such as race) or to compare different geographical areas (ie, zip code, regional, or state-level differences). In contrast, ED billing data from individual hospitals are valuable when there is a desire to understand the characteristics of children who use the ED for asthma care and the pattern of ED use in the local population, as well as when evaluating local QI initiatives.

Obviously, the solution to the inability to calculate population-based ED-visit rates would be to include all the relevant hospitals within the region or, better yet, to have a statewide system for reporting ED billing data. However, we found that expanding the surveillance system to include other hospitals was problematic. We first attempted to do this by partnering with a local asthma coalition in the community and then jointly contacting other local hospitals to obtain ED billing data. We encountered several challenges that illustrate some of the difficulties in developing surveillance systems that involve multiple hospitals and organizations. Although obtaining approval from individual hospital institutional review/privacy boards was time-consuming, it was facilitated greatly by only requesting deidentified aggregate data for public health surveillance purposes. However, we then encountered difficulties in obtaining the data from the hospital billing departments; our data requests were often given low priority, and when our requests were addressed, the data provided were frequently not in a format that met our specifications.

Our challenges were similar to those outlined in a

previous report on a pilot ED billing system developed in Milwaukee, Wisconsin.<sup>19</sup> The authors of that report provided several recommendations for developing such a system, including spending at least 12 months in planning and preparation, identifying local partners (such as an asthma coalition and a physician champion at each hospital), focusing on the largest institutions first, addressing human subjects' concerns, and compensating hospitals for preparing the data. We concur with these recommendations but believe that a larger system that requires the involvement of multiple autonomous hospitals is unlikely to be successful without an unusual degree of buy-in from hospitals and the asthma community at large.

An alternative approach to obtaining ED surveillance data is to either mandate the reporting of ED billing data or identify sufficient financial resources to promote a voluntary system. Approximately half of the 20 states that have access to statewide ED encounter data have a mandatory system, as opposed to a voluntary system.<sup>18</sup> The Michigan Asthma Advisory Committee, a statewide advisory board to the Michigan Department of Community Health, has recommended that a statewide system for ED data collection be developed in Michigan. However, the development of such a system requires strong support from a broad array of stakeholders within the state (community-based organizations, medical and public health-based professional organizations, as well as state and local government) to promote the legislative language for a mandatory system or, alternatively, to identify adequate financial resources for a voluntary system.

## CONCLUSIONS

We were able to successfully implement a pilot ED surveillance system for childhood asthma visits by using billing data obtained from a single physician billing company. The system provided useful information on the burden of asthma among children visiting the ED, including demographic and time-related trends. The development of ED-based surveillance systems for childhood visits for asthma using billing data is recommended; however, such systems require backing from a broad range of stakeholders to develop the necessary legislative and/or financial support.

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