ORIGINAL ARTICLE

Emergency Department Visits Attributable to Asthma in North Carolina, 2008

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BACKGROUND Asthma is a prevalent, morbid, and costly chronic condition that may result in preventable exacerbations requiring emergency department (ED) care. In North Carolina we have limited information about the frequency and characteristics of asthma-related ED visits.

METHODS We estimated statewide population-based asthma-related ED visit rates in North Carolina, both overall and by age, sex, geography, insurance, and season.

RESULTS There were 86,700 asthma-related ED visits in North Carolina in 2008, representing 2.1% of all ED visits in the state. Substantial geographic variation existed, with rates ranging from 1.3 visits per 1,000 population in Ashe County to 21.0 visits per 1,000 population in Pasquotank County. Rates by age, sex, and month were consistent with the findings of other studies. Of asthma ED visits, 4.8% were preceded by another asthma visit to the same ED within 14 days. The proportion of patients who made at least 1 additional asthma visit to the same ED within 365 days was 23.5%; 11.6% of asthma ED patients met at least 1 criterion for being at high risk of hospitalization or death.

LIMITATIONS We lacked data on ED visits for asthma outside North Carolina, information about the accuracy of asthma diagnosis in the ED, patient identifiers that would allow linking across EDs, data on race or ethnicity, and data on urgent care utilization.

CONCLUSIONS We have characterized the burden of asthma in EDs across North Carolina, by county and among key subpopulations. These data can be used to target and evaluate local and statewide asthma-control policy efforts.

Asthma is a prevalent chronic disease that is associated with substantial morbidity, health care utilization, and cost [1-3]. Both the US Department of Health and Human Services and the Centers for Disease Control and Prevention recognize that surveillance of population-level trends in prevalence, health care utilization, and morbidity can support efforts to plan for and reduce the consequences of asthma [3-5]. Currently, national estimates of asthma prevalence and health care utilization allow comparisons across states and regions [6-8] but cannot be used by states to support more targeted efforts to reduce the burden of asthma.

The North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT) collects statewide population data on all emergency department (ED) visits [9, 10]. ED visits are critical to asthma surveillance, because they may identify preventable asthma exacerbations and because they may be the occasion for implementation of evidence-based public health interventions that can support state and local efforts to improve asthma control [11-13]. Using 2008 NC DETECT data, we examine statewide patterns of ED use in North Carolina for asthma, both overall and by age, sex, geography, insurance status, and month (seasonality). We also identify patterns of frequent use of the ED for asthma treatment.

Methods

Data Sources

We used NC DETECT [10] to identify all visits to civilian, acute care, hospital-affiliated EDs in North Carolina made by residents of the state during 2008. While analysis focuses on ED visits made by NC residents during 2008, additional NC DETECT data was used to identify additional ED visits made by the patients between December 1, 2007 and December 31, 2009. NC DETECT received data for an estimated 99.5% of all ED visits in the state that year. We used county-level population estimates for 2008 from the North Carolina Office of State Budget and Management [14]. Our estimate of the percentage of North Carolina residents who were uninsured in 2008 comes from Current Population Survey data [15].

Measures

Asthma ED visits. We defined asthma ED visits as visits with an ICD-9-CM code of asthma (493.xx) as the first or second diagnosis, a strategy supported by our analysis of NC DETECT visit data (abstract under review). With the NC DETECT data, we were able to link visits made by an individual to the same facility, but not visits made by an individual to different facilities, because there is no common patient identifier used by all facilities. We began by prospectively counting the number of asthma ED visits made by each patient to the same facility during the 365 days following his

Electronically published February 8, 2013.

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N C Med J. 2013;74(1):9-17.
0029-2559/2013/74101

or her index visit, defined as the patient's first visit to that facility in 2008.

We identified patients as being at high risk for hospitalization or death based on the elements from the National Asthma Education and Prevention Program care guidelines definition that could be measured in our data [13]. Specifically, a patient was considered "high risk" if he or she met at least one of the following criteria: The patient made 2 or more asthma ED visits to the facility within a 30-day period; the patient made 3 or more asthma ED visits to the facility within 365 days of the index visit; or the patient made 2 or more asthma ED visits within 365 days of the index visit and at least 2 of those visits resulted in a hospital admission.

Return visits. Return visits were defined as those preceded by a previous asthma ED visit by the same patient to the same facility within the preceding 3, 14, or 30 days.

Stratification variables. Stratification variables included age, sex, county, urbanicity [16], geographic region (Eastern, Western, or Piedmont area) [17], payment method (eg, private insurance, Medicaid, self-pay), ED disposition (eg, discharged home, admitted), and chief complaint (a free text field in which the triage nurse documents the primary reason for the ED visit). The chief complaints were standardized using a validated text processor that addresses acronyms (eg, *SOB* and *SHOB* for *shortness of breath*), truncations (eg, *diff br* for *difficulty breathing*) and misspellings (eg, *dypnia* for *dyspnea*) [18]. Standardized chief complaints were grouped into 5 clinically homogenous categories—asthma, dyspnea, cold, cough, or injury—by one of the authors (DT). Table 1 (online version only) shows the free text search terms used to find complaints in those categories and provides examples of chief complaints included in each category.

TABLE 1.
Chief Complaints by Category Used in Chief Complaint Analysis

This table is available in its entirety in the online edition of the NCMJ.

Analysis

Data were analyzed using SAS 9.2 (SAS, Cary, NC), Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA) and ArcGIS 9.2 (ESRI, Redlands, CA). Because NC DETECT represents population data, we do not include P values when reporting comparisons. This project was approved as exempted research by the Institutional Review Board of the University of North Carolina at Chapel Hill.

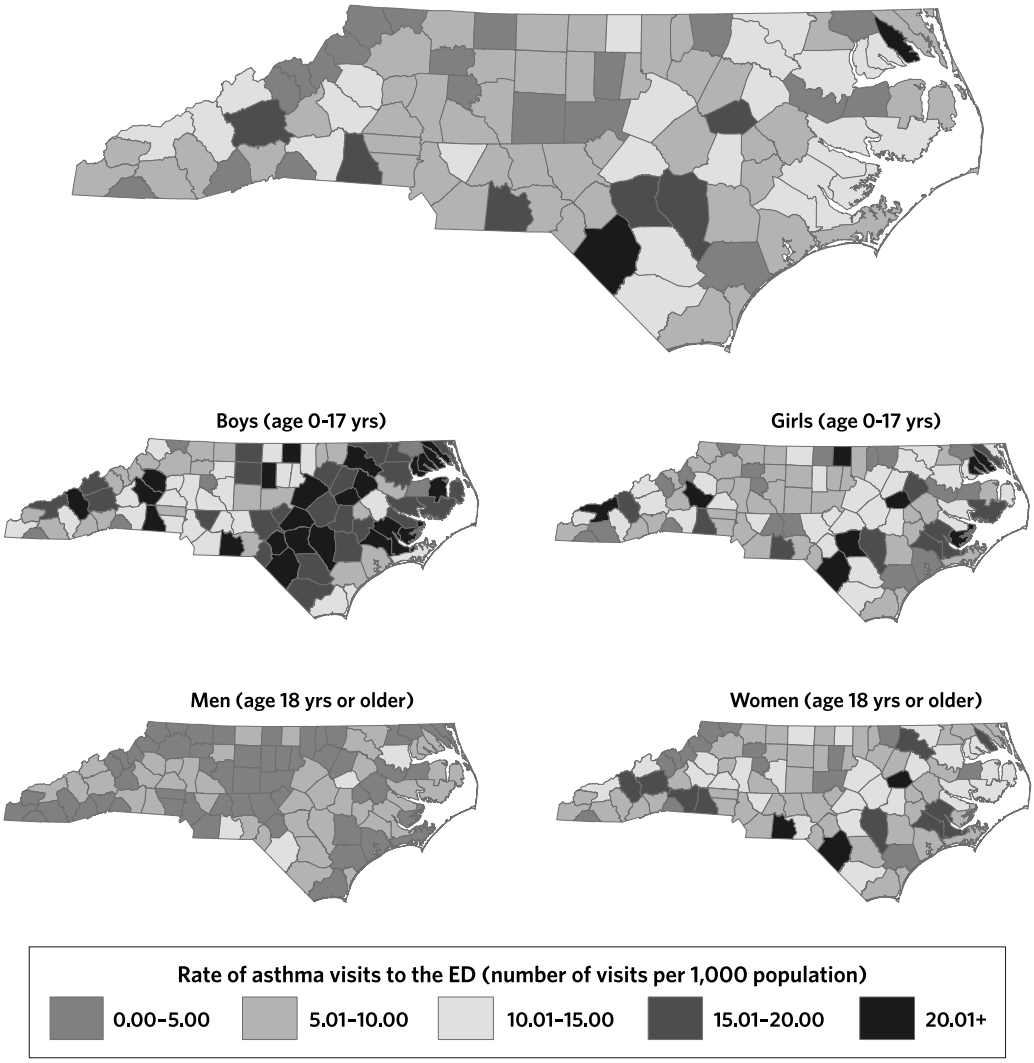
We present counts of ED visits for asthma in North Carolina in 2008 (by age, sex, geographic region, payment method, and ED disposition, and overall), comparing them with counts of ED visits for any reason, in Table 2; addi-

TABLE 2.
Number of Emergency Department (ED) Visits for Asthma in North Carolina in 2008 Compared With Total Number of ED Visits for Any Reason

Population characteristic	Asthma ED visits[a]	All ED visits
	N (%)	N (%)
Age (years)		
0-1	4,303 (5.0)	195,518 (4.8)
2-4	7,482 (8.6)	154,075 (3.8)
5-9	9,666 (11.2)	158,717 (3.9)
10-14	6,672 (7.7)	143,137 (3.5)
15-17	3,805 (4.4)	134,068 (3.3)
18-24	10,098 (11.7)	514,715 (12.7)
25-44	23,814 (27.5)	1,240,374 (30.7)
45-64	15,029 (17.3)	875,070 (21.6)
65 +	5,798 (6.7)	627,012 (15.5)
Unknown/missing	33 (<0.1)	167 (<0.1)
Sex		
Female	49,592 (57.2)	2,266,928 (56.1)
Male	37,084 (42.8)	1,775,537 (43.9)
Unknown/missing	24 (<0.1)	388 (<0.1)
Region		
Eastern North Carolina	29,563 (34.1)	1,238,304 (30.6)
Piedmont North Carolina	46,210 (53.3)	2,257,539 (55.8)
Western North Carolina	10,729 (12.4)	535,934 (13.3)
Unknown/missing	198 (0.2)	11,076 (0.3)
Payment method		
Uninsured		
Self-pay (no insurance)	19,480 (22.5)	974,563 (24.1)
Insured	63,199 (72.9)	2,807,548 (69.4)
Private insurance	21,386 (24.7)	903,145 (22.3)
Medicare	10,020 (11.6)	1,055,484 (26.1)
Medicaid	29,026 (33.5)	756,005 (18.7)
Other government payments or workers' compensation	2,767 (3.2)	92,914 (2.3)
Other/unknown/missing	4,021 (4.6)	260,742 (6.4)
Disposition		
Discharged to home or self-care	70,132 (80.9)	3,036,673 (75.1)
Admitted to a hospital department	10,252 (11.8)	527,931 (13.1)
Left without treatment or against medical advice	1,225 (1.4)	133,210 (3.3)
Transferred to another location	543 (0.6)	70,621 (1.7)
Placed in observation (not admitted)	355 (0.4)	15,552 (0.4)
Died	28 (<0.1)	7,918 (0.2)
Other	64 (<0.1)	21,366 (0.5)
Unknown/missing	4,101 (4.7)	229,582 (5.7)
Total	86,700	4,042,853

[a]Asthma ED visits are those that had an ICD-9-CM code of 493.00-493.99 as the first or second diagnosis.

FIGURE 1.
Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008 by County



Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

tional data (medians, means, and standard deviations, and the frequency of chief complaints across all asthma ED visits) are available at http://www.ncdetect.org/NCMJ_AsthmaEDVisitsInNC2008.pdf. In Figure 1, we present maps of annual asthma ED visit rates (the number of visits per 1,000 population) by county, both overall and by age and sex. Information about ED visit rates by county is presented in Table 3 (online version only) and Table 4 (online version only). Finally, to examine seasonality, we present asthma ED visit rates (the number of visits per 1,000 population)) for every calendar month of 2008 by age (Figure 2), sex (Figure 3, online version only), region (Figure 4, online version only), and insurance status (Figure 5, online version only). The denominators for rates related to age, sex, and region are based on midyear state population estimates [14], whereas rates related to insurance status are based on estimates of the proportion of people living in North Carolina during 2008 with and without insurance [15].

To examine frequent use, we first report the number and characteristics of individuals making repeat asthma ED visits in 2008 (Table 5). We then describe patients meeting at least 1 criterion for high risk of hospitalization or death, comparing them by age, sex, region, and payment method to those not considered to be at high risk (Table 6). We conducted similar analyses comparing visits identified as return visits to visits that were not preceded by another asthma visit in the previous 3, 14, or 30 days (Table 5).

Results

There were 86,700 ED visits with a first or second diagnosis of asthma in 2008, representing 2.1% of all ED visits in North Carolina. The rate of asthma ED visits in the state in 2008 was 9.4 per 1,000 population. Asthma visits were more likely to be made by people who were younger and

TABLE 3.
Emergency Department (ED) Visit Rates in North Carolina Counties in 2008, for Asthma Visits and for All Visits Regardless of Diagnosis

This table is available in its entirety in the online edition of the NCMJ.

Note: ED visit rates are the number of ED visits per 1,000 population. Asthma ED visit rates include visits that had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis. Overall ED visit rates include all visits regardless of diagnosis.

TABLE 4.
Ranking of Counties by Asthma Emergency Department (ED) Visit Rate, Overall ED Visit Rate, and Ratio of Asthma ED Visit Rate to Overall ED Visit Rate

This table is available in its entirety in the online edition of the NCMJ.

Note: ED visit rates are the number of ED visits per 1,000 population; the actual rates can be found in Table 2. Here, in each column, a rank of 1 indicates the highest ED visit rate in the state and a rank of 100 the lowest ED visit rate. Asthma ED visit rates include visits had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis. Overall ED visit rates include all visits regardless of diagnosis.

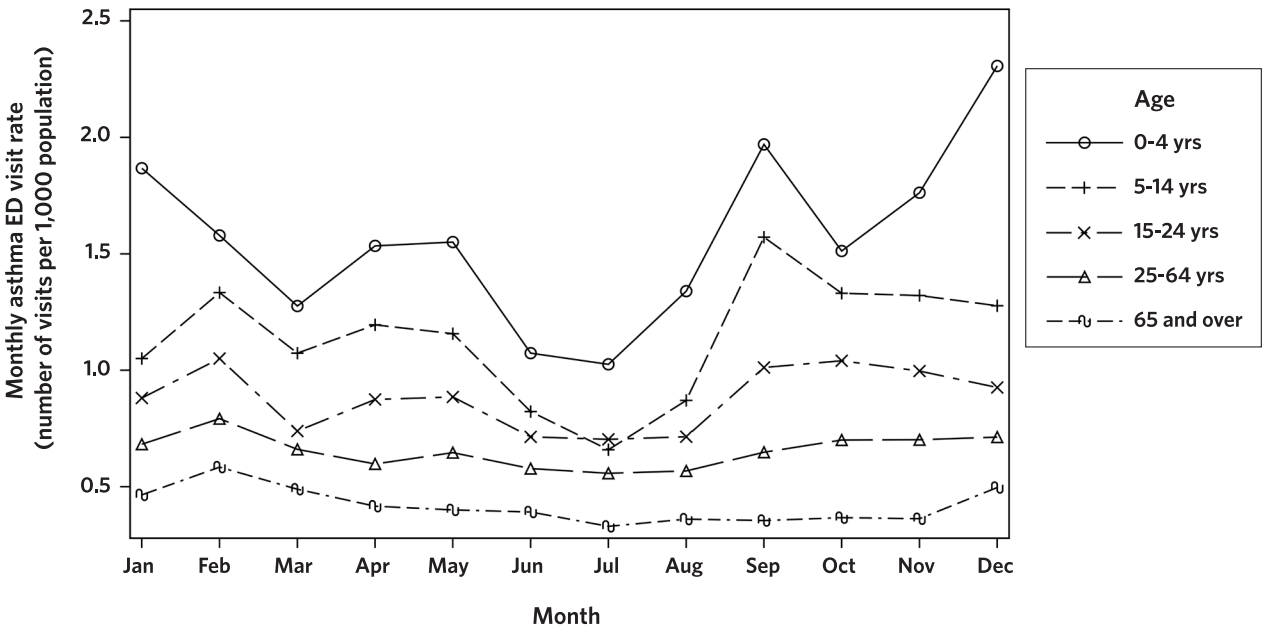
who used Medicaid as their payment method (Table 2). The 6 most common chief complaint categories accounted for 64% of the asthma ED visits: Asthma accounted for 21%; shortness of breath, 12%; dyspnea, 11%; cough, 10%; chest pain, 5%; and wheezing, 5%.

Substantial variation exists in asthma ED visit rates geographically; overall rates for individual counties in 2008 range from 1.9 visits per 1,000 population to 21.0 visits per 1,000 population (Figure 1). The 6 counties with the highest asthma ED visit rates that year were Pasquotank, Robeson, Wilson, Anson, Cleveland, and Cumberland (Table 4, online version only). There appears to be no consistent relationship between the asthma ED visit rate for a county and the rate of ED visits for all diagnoses in that county. The asthma ED visit rates in the Western, Piedmont, and Eastern regions were 9.4, 8.5, and 11.1 visits per 1,000 population, respectively. The asthma ED visit rates in urban versus rural counties were 9.4 and 9.1 visits per 1,000 population, respectively.

Across North Carolina in 2008, asthma ED visit rates among children ages 0-17 years and adults age 18 and older were 14.5 and 7.8 visits per 1,000 population, respectively. The median age of individuals making asthma ED visits was 25.5 (mean=29.0, SD=28.5); the median age for those making ED visits for any reason was 36 years (mean=38.0, SD=24.3). The asthma ED visit rate for males was 8.2 visits per 1,000 population, and for females it was 10.5 visits per 1,000 population. Taking age and sex together, asthma ED visit rates among boys ages 0-17 years, girls ages 0-17 years, men age 18 years or older, and women age years 18 or older were 16.7, 11.1, 5.1, and 10.2 visits per 1,000 population, respectively. The asthma ED visit rate for those who were insured was 8.1 visits per 1,000 population, compared with 13.7 visits per 1,000 population among those with no insurance.

Asthma visit rates were highest among children 4 years

FIGURE 2.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Age



Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

FIGURE 3.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Sex

This figure is available in its entirety in the online edition of the NCMJ.

Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

FIGURE 4.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Region

This figure is available in its entirety in the online edition of the NCMJ.

Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

FIGURE 5.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Insurance Status

This figure is available in its entirety in the online edition of the NCMJ.

Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

old or younger and varied considerably by month (Figure 2). There were 2 substantial peaks for children 4 years of age or younger—in September, and in December through February, and there were also peaks in September and February for children aged 5-14 years. A less pronounced third peak was observed in April-May for children age 4 or younger. As shown in Figures 3, 4, and 5 (online version only), fairly minor variations in seasonal patterns are seen by sex, by region, and by insurance status, although the overall frequency of visits by these variables is different, as reported above.

Of the 67,906 patients who made an asthma ED visit in calendar year 2008, 75.6% had only the 1 asthma ED visit to that facility, while 15.1%, 4.7%, 1.8%, and 2.0% of asthma ED patients made 2, 3, 4, and 5 or more asthma ED visits to the same facility within 365 days following the first (index) visit, respectively.

A total of 7,886 patients (11.6%) making asthma ED visits met at least 1 criterion for high risk of hospitalization or death (see Table 6). These high-risk individuals were more likely than other asthma patients to be in the age group 18-64 years, to live in the Eastern region of the state, and to have had Medicaid coverage for at least 1 of their visits (39.8% of those at high risk had at least 1 Medicaid payment across multiple visits, whereas only 31.9% of those not at high risk had a Medicaid payment). A little more than 60% of the individuals who met any 1 criterion for high risk also met at least 1 other criterion; 11.6% of all patients making asthma ED visits in 2008 met at least 1 of the 3 criteria, 5.3% met at least 2 criteria, and 0.7% (455 patients) met all 3.

The proportions of patients making return asthma-related ED visits within 3, 14, and 30 days of a preceding visit were 1.8%, 4.8%, and 8.2%, respectively. Patients making return visits within any of the intervals were more likely to be 18-44 years of age, were more likely to reside in the Eastern region of the state, and were less likely to reside in the Piedmont. Individuals who returned within 14 days were more likely to have no insurance while those not returning to the ED were more likely to have private insurance.

Discussion

To our knowledge, this is the first statewide, population-based surveillance study of asthma ED visits in the United States. In 2008, the 86,700 asthma-related ED visits made in North Carolina accounted for approximately 2% of all ED visits. Although the asthma ED visit rate in North Carolina is higher than the national average (9.4 vs. 6.7 visits per 1,000 population), in North Carolina asthma ED visits make up only a slightly greater proportion of all ED visits than is the case nationally (2.1% versus 1.8%) [19]. Notably, the annual asthma ED visit rates in North Carolina are substantially higher than the goals set for Healthy People 2020 for children younger than 5 years (18.8 versus 9.6 visits per 1,000 population), for those 5-64 years of age (9.3 versus 4.9 visits per 1,000 population), and for those age 65 or older (5.0 versus 1.3 visits per 1,000 population) [20].

Interestingly, more than 4,000 ED visits with an asthma diagnosis were made by children younger than 2 years. This figure is surprisingly high and may be related to the inconsistency in assigning asthma diagnoses (versus other diagnoses such as reactive airway disease) to this age group [21]. The clinical literature does not support the diagnosis of asthma in the majority of children under the age of 2 years who may wheeze with a viral illness, because many do not go on to develop asthma [22]. However, we found that ED clinicians do frequently assign asthma diagnoses to children in this age group.

More broadly, the patterns we found in ED visit rates among children and adults by sex are consistent with the differences between children and adults and the differences between males and females described in other studies. Specifically, although asthma ED visit rates are higher among females than males overall, they are higher in males than in females before puberty, with a reversal in adulthood [6, 23-25].

Although most chief complaints documented were respiratory, only 21% were listed as "asthma" specifically. This may be because there is no national standard for chief complaint documentation in ED records [26]. Some ED information systems allow free text entry of chief complaints while others use drop-down lists (only some of which include asthma, while others may only have terms such as *wheezing* or *shortness of breath*). Thus, the observed variability in chief

TABLE 5.
Counts of Return Emergency Department (ED) Visits for Asthma[a] Within 3 or 14 Days Compared With Counts of ED Visits for Asthma That Were Not Preceded by an Asthma Visit Within 3 or 14 Days

Population characteristic	Return visits within 3 days	Visits not constituting a return within 3 days	Return visits within 14 days	Visits not constituting a return within 14 days
	N (%)	N (%)	N (%)	N (%)
Age (years)				
0-1	69 (4.4)	4,234 (5.0)	116 (2.8)	4,187 (5.1)
2-4	134 (8.5)	7,348 (8.6)	228 (5.5)	7,254 (8.8)
5-9	156 (9.9)	9,510 (11.2)	277 (6.7)	9,389 (11.4)
10-14	116 (7.3)	6,556 (7.7)	217 (5.3)	6,455 (7.8)
15-17	62 (3.9)	3,743 (4.4)	134 (3.3)	3,671 (4.5)
18-24	202 (12.8)	9,896 (11.6)	517 (12.5)	9,581 (11.6)
25-44	526 (33.3)	23,288 (27.4)	1,585 (38.4)	22,229 (26.9)
45-64	249 (15.7)	14,780 (17.4)	834 (20.2)	14,195 (17.2)
65 +	67 (4.2)	5,731 (6.7)	217 (5.3)	5,581 (6.8)
Unknown/Missing	1 (<0.1)	32 (<0.1)	1 (<0.1)	32 (<0.1)
Sex				
Female	890 (56.3)	48,702 (57.2)	2,299 (55.7)	47,293 (57.3)
Male	692 (43.7)	36,392 (42.8)	1,827 (44.3)	35,257 (42.7)
Unknown	0 (0)	24 (<0.1)	0 (0)	24 (<0.1)
Region				
Eastern North Carolina	610 (38.6)	28,953 (34.0)	1,648 (39.9)	27,915 (33.8)
Piedmont North Carolina	780 (49.3)	45,430 (53.4)	2,012 (48.8)	44,198 (53.5)
Western North Carolina	186 (11.8)	10,543 (12.4)	454 (11.0)	10,275 (12.4)
Unknown/missing	6 (0.4)	192 (0.2)	12 (0.3)	186 (0.2)
Payment method				
Non-insured				
Self-pay (no insurance)	356 (22.5)	19,124 (22.5)	1,081 (26.2)	3,825 (4.6)
Insured				
Private insurance	325 (20.5)	21,061 (24.7)	749 (18.2)	20,637 (25.0)
Medicare	164 (10.4)	9,856 (11.6)	562 (13.6)	9,458 (11.5)
Medicaid	624 (39.4)	28,402 (33.4)	1,448 (35.1)	27,578 (33.4)
Other government payments/ Workers compensation	42 (2.7)	2,725 (3.2)	90 (2.2)	2,677 (3.2)
Other/unknown/missing	71 (4.5)	3,950 (4.6)	196 (4.8)	3,825 (4.6)
Total	1,582[b]	85,118	4,126[c]	82,574

Note: Data are for asthma ED visits by North Carolina residents in 2008. Percentages have been rounded and therefore do not always add up to 100%.
[a]Asthma ED visits are those that had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis. Return visits are ED visits in which the person had a previous asthma-related ED visit within the previous 3 days or the previous 14 days.
[b]Return visits within 3 days represented 1.8% of all asthma visits to the ED during 2008.
[c]Return visits within 14 days represented 4.8% of all asthma visits to the ED during 2008.

complaints found in this study is not surprising.

Given the high population density of the piedmont region, it is not surprising that more than 50% of asthma ED visits in 2008 occurred there. However, the annual asthma ED visit rates in the Western and Eastern regions were higher. This may, in part, reflect the fact that those regions are more rural and residents therefore have less access to primary care. Although there is substantial geographic variation in asthma-related ED visit rates, counties with high overall asthma ED visit rates have high rates across all age groups and both sexes. This may suggest the presence of systemic factors affecting the entire population, such as environmental (eg, external or ambient) factors that trigger exacerbations, allergens, variability in incidence rates of influenza, and/or disparate access to high-quality preventive care, asthma management, and acute health care.

TABLE 6.
A Comparison of Asthma Emergency Department (ED) Patients at High Risk of Asthma-Related Hospitalization or Death With Those Not at High Risk

Population characteristic	Patients at high risk[a]	Patients not at high risk
	N (%)	N (%)
Criterion for high risk that was met[b]		
≥ 2 asthma ED visits within 30 days	5,116 (64.9%)	
≥ 3 asthma ED visits within 365 days	5,742 (72.8%)	
> 2 asthma ED visits within 365 days, at least 2 of which resulted in hospital admission	1,111 (14.1%)	
Age (years)		
0-1	414 (5.3)	3,196 (5.3)
2-4	659 (8.4)	5,365 (8.9)
5-9	781 (9.9)	7,109 (11.8)
10-14	469 (6.0)	5,082 (8.5)
15-17	293 (3.7)	2,867 (4.8)
18-24	988 (12.5)	6,812 (11.4)
25-44	2,444 (31.0)	14,982 (25.0)
45-64	1,396 (17.7)	10,078 (16.8)
65 +	441 (5.6)	4,499 (7.5)
Unknown/Missing	1 (<0.1)	30 (<0.1)
Sex		
Female	4,608 (58.4)	34,227 (57.0)
Male	3,278 (41.6)	25,769 (42.9)
Unknown/Missing	0 (0.0)	24 (<0.1)
Region		
Eastern North Carolina	2,797 (35.5)	19,645 (32.7)
Piedmont North Carolina	4,117 (52.2)	32,474 (54.1)
Western North Carolina	956 (12.1)	7,775 (13.0)
Unknown/missing	16 (0.2)	126 (0.2)
Payment method		
Non-insured		
Self-pay (no insurance)	1,354 (17.2)	12,276 (20.5)
Insured		
Private insurance	1,175 (14.9)	16,103 (26.8)
Medicare	847 (10.7)	6,697 (11.2)
Medicaid	2,358 (29.9)	18,653 (31.1)
Other government payments/ Workers compensation	154 (2.0)	2,005 (3.3)
Multiple payment methods[c]	1,741 (22.1)	1,550 (2.6)
Other/unknown/missing	257 (3.3)	2,736 (4.6)
Total	7,886[d]	60,020

Note: Data are for North Carolina residents who made an asthma-related visit to an ED in the state in 2008. Asthma-related ED visits are those that had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis.
[a]High risk patients were those who met one or more of the following criteria: 3 or more asthma ED visits to the same ED within a 365-day period; 2 or more visits to the same ED within a 30-day period; or 2 or more visits to the same ED within in a 365-day period, at least 2 of which resulted in a hospital admission.
[b]Some patients met more than one criterion.
[c]Patients counted as having multiple payment methods were those having at least 2 different payment methods for at least 2 consecutive visits to the ED during 2008.
[d]High-risk patients constituted 11.6% of all asthma ED patients with index visits during 2008.

Notably, 7 counties that had high asthma ED visit rates overall in 2008 border Tennessee and may experience the hypothesized "down wind" effect of the coal-power plants there [27].

Counties with higher asthma ED visit rates were largely those with higher asthma hospitalization rates [28] and higher health risks [29], particularly for boys 0-17 years old. This may be due to individual and community factors in these counties, such as racial or ethnic disparities (eg, higher prevalence of asthma among Native Americans), lack of access to appropriate health care for asthma (eg, an inadequate number of physicians specializing in chronic lower respiratory diseases), and higher poverty rates. These issues have important implications for addressing current and future public health policies regarding asthma management and control.

Our findings regarding seasonality of asthma-related ED visits are generally consistent with those in the published literature [30-37], with some notable differences. For example, we observed the well-documented "September epidemic" in which children 14 years of age or younger have peaks in asthma-related ED use during that month. However, the September peak appears to be more dramatic in 0-4 year olds in North Carolina than in children that age in Canada [32, 36]. Moreover, a December peak observed in Canadian adults is much less dramatic in North Carolina. These differences between North Carolina and Canada may reflect childcare practices, environmental triggers, or allergies. The December/January peak we observed in children younger than 4 years of age has also been reported in New York City [37]. Although seasonal patterns of asthma ED visits are quite consistent among individuals 5 years old or older, there may be more variation than has been recognized among children 4 years old or younger.

We examined 3 aspects of frequent use: number of asthma ED visits within 365 days, high-risk patients, and return visits. Approximately 24% of individuals with at least 1 asthma ED visit in 2008 had 2 or more asthma ED visits to the same facility within 365 days. To the best of our knowledge, this is the first population-based estimate of repeated ED use for asthma. Prior studies have reported a somewhat higher rate of repeat ED visits within a year. This is probably because many of those other studies report rates of repeat ED visits for any reason rather than just repeat visits for asthma, or reflect visit rates among inner-city and other high-risk subpopulations, or rely on self-reported ED use [38-40].

We identified more than 8% of asthma ED visits as return visits for asthma within 30 days. Our findings are similar to those in the published literature, with the exception that fewer of the return visits in North Carolina occur as soon as within 3 days [41, 42]. Geographically, return visits are slightly more likely to be made by patients living in the Eastern region of North Carolina and less likely to be made by individuals in the Piedmont region.

Limitations

First, we lacked data on ED visits made by North Carolinians to EDs outside North Carolina and therefore may have underestimated asthma ED visit rates. Second, we lacked clinical data to confirm the accuracy of asthma-related diagnoses in the ED. Because there is no consistent definition of an asthma ED visit using administrative data, we included all ED visits with an asthma ICD-9-CM diagnosis code (493.xx) in the first or second position. This strategy was supported by our clinical experience and by our internal analyses of NC DETECT data, including information on chief complaint, procedure codes, and additional diagnoses; our preliminary analyses support this strategy (abstract under review). Third, we lacked patient identifiers that would allow us to link visits across facilities. This may have resulted in our underestimating the number of return and repeat visits made by individuals and overestimating the number of individuals making asthma ED visits. Any bias may have been minimized by the fact that there are no incentives for patients to use multiple facilities. Fourth, NC DETECT does not contain data on race and ethnicity, which are key factors in disparities in asthma outcomes [19]. Finally, we lacked data on utilization of urgent care centers. Given that these centers are used for acute exacerbations, our estimates underestimate the burden of asthma in North Carolina.

Conclusions

Given the importance of conducting regular and rapid surveillance for asthma, NC DETECT is a valuable tool. We have quantitatively characterized the burden of asthma in North Carolina overall, by county, and by key subpopulations. Our findings have important implications for data-driven, public health surveillance and programmatic efforts at the local and state levels. For example, these data can be used to investigate asthma management issues, including access to asthma medication for disease management and prevention of asthma exacerbations and episodes. In addition, the analysis of county-level ED visit rates may help counties with high rates develop community-based efforts to decrease costly ED visits for asthma. Furthermore, this analysis can be replicated over time to support evaluation and improvement of local and statewide asthma control policy efforts. Finally, by estimating the prevalence of measurable criteria that identify patients with asthma who are at high risk of hospitalization or death [43-45], we can open discussion within North Carolina and inspire future work to develop strategies that target these at-risk patients. NCMJ

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Acknowledgments

This project was supported by a Gillings Innovation Laboratory award from the UNC Gillings School of Global Public Health. None of the authors have relevant conflicts of interest. Effort by KHL was partially supported by Award Number KL2RR025746 from the National Center for Research Resources. MW was supported by a VA Research Career Scientist Award from the VA Health Services Research and Development Service. WL was partially supported by CDC Grant/Cooperative Agreement 1U59EH000518-01. NC DETECT data were provided by the North Carolina Public Health Data Group. The content of this paper is solely the responsibility of the authors and does not necessarily represent the official views of the National Center for Research Resources, the National Institutes of Health, the Centers for Disease Control and Prevention, the North Carolina Public Health Data Group, or NC DETECT. The authors take sole responsibility for the scientific validity and accuracy of methodology, results, statistical analyses, and conclusions presented.

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TABLE 1.
Chief Complaints by Category Used in Chief Complaint Analysis

Chief Complaint Category	Free text search terms ("*" indicates wildcard)	Examples of chief complaints included in category)
Asthma	*asthma*	Asthma
		Asthma attack
		Asthma exacerbation
		Asthma flare
		Asthma problems
		Asthma/SOB
		Asthma NOS
		Asthma NOS w (AC) Exac
		Hx asthma
Dyspnea	*dyspnea*	SOB
	distress respiratory	Short of breath
	breath	Shortness of breath
		Dyspnea
		Difficulty breathing
		Diff breathing
		DB
		Trouble breathing
		Distress respiratory
		Abnormal breathing
		Labored breathing
Cold	*cold*	Common cold
		Cold symptoms
		Coldlike symptoms
		Cold Sx
		Chest cold
Cough	*cough*	Cough
		Coughing
		Cough/congestion
		Fever/cough
		Cough/wheezing
Injury	*fall*	MVC
	laceration	MVA
	injur	Motor vehicle crash
	traumatic	Motor vehicle accident
	accident	Car accident
	bite	Fall
	sting	Laceration
		Head injury
		Ankle injury
		Extremity injury
		Arm pain, traumatic
		Insect bite
		Spider bite
		Bee sting
		Bite injury
		Dog bite

TABLE 3.
Emergency Department (ED) Visit Rates in North Carolina Counties in 2008, for Asthma Visits and for All Visits Regardless of Diagnosis

			Asthma ED visit rates						
			Sex/age in yrs						
County	Region	Urban/Rural	M/<18	F/<18	M/≥18	F/≥18	Total population	Overall ED visit rates	Ratio of asthma ED visit rate to overall ED visit rate
Alamance	Piedmont	Urban	20.3	12.5	4.3	9.8	9.4	443.8	0.021
Alexander	Piedmont	Rural	10.4	8.8	5.5	9.2	7.9	476.6	0.017
Alleghany	Western	Rural	4.7	2.9	1.1	2.4	2.2	532.8	0.004
Anson	Piedmont	Rural	24.6	17.5	11.6	20.3	17.1	690.4	0.025
Ashe	Western	Rural	11.5	6.8	2.4	4.0	4.4	571.0	0.008
Avery	Western	Rural	6.1	2.5	1.1	3.8	2.7	470.0	0.006
Beaufort	Eastern	Rural	16.5	13.6	6.8	13.1	11.3	605.8	0.019
Bertie	Eastern	Rural	17.9	10.0	10.7	11.2	11.7	665.7	0.018
Bladen	Eastern	Rural	16.1	13.5	7.0	9.9	10.1	574.3	0.018
Brunswick	Eastern	Rural	14.4	8.8	3.3	7.0	6.4	461.8	0.014
Buncombe	Western	Urban	17.4	14.7	9.0	19.8	15.0	355.7	0.042
Burke	Western	Rural	27.5	20.0	9.1	13.7	14.2	562.0	0.025
Cabarrus	Piedmont	Urban	15.6	11.0	5.4	13.2	10.5	491.9	0.021
Caldwell	Western	Rural	21.4	13.0	5.4	10.7	10.2	572.2	0.018
Camden	Eastern	Rural	23.8	16.7	1.3	7.1	7.6	291.7	0.026
Carteret	Eastern	Rural	11.2	7.7	2.9	6.1	5.4	473.1	0.012
Caswell	Piedmont	Rural	10.3	4.3	2.8	6.5	5.2	278.5	0.019
Catawba	Piedmont	Urban	14.3	12.7	5.8	11.2	9.8	480.2	0.020
Chatham	Piedmont	Rural	9.6	7.5	2.2	3.8	4.2	297.6	0.014
Cherokee	Western	Rural	12.7	6.5	3.7	6.7	6.1	382.6	0.016
Chowan	Eastern	Rural	30.8	13.5	9.7	11.6	13.3	604.8	0.022
Clay	Western	Rural	3.4	1.2	1.2	2.4	1.9	230.8	0.008
Cleveland	Piedmont	Rural	28.9	19.9	8.9	19.0	16.7	613.8	0.027
Columbus	Eastern	Rural	19.2	12.5	5.7	10.6	10.2	636.0	0.016
Craven	Eastern	Rural	24.5	19.1	7.2	16.7	14.7	551.0	0.027
Cumberland	Eastern	Urban	43.1	26.8	5.3	13.1	16.1	379.3	0.042
Currituck	Eastern	Rural	17.7	12.4	3.8	8.9	8.3	213.6	0.039
Dare	Eastern	Rural	18.5	10.8	5.4	11.1	9.5	389.4	0.025
Davidson	Piedmont	Urban	13.5	8.1	4.0	11.6	8.6	453.0	0.019
Davie	Piedmont	Rural	4.8	4.5	1.7	4.0	3.3	291.9	0.011
Duplin	Eastern	Rural	16.3	8.0	4.7	9.0	8.3	463.8	0.018
Durham	Piedmont	Urban	13.8	8.3	4.7	8.8	7.9	400.6	0.020
Edgecombe	Eastern	Rural	25.0	15.6	6.8	13.0	12.9	673.8	0.019
Forsyth	Piedmont	Urban	14.7	9.0	5.0	9.8	8.6	423.7	0.020
Franklin	Piedmont	Rural	16.7	10.7	4.6	9.6	8.7	452.2	0.019
Gaston	Piedmont	Urban	10.6	6.5	3.7	7.5	6.4	480.1	0.013
Gates	Eastern	Rural	4.2	2.9	1.6	5.7	3.7	199.3	0.019
Graham	Western	Rural	9.7	14.6	4.2	8.4	7.6	451.1	0.017
Granville	Piedmont	Rural	13.9	6.4	4.9	8.7	7.5	400.5	0.019
Greene	Eastern	Rural	9.6	9.8	2.6	7.6	6.1	331.8	0.018
Guilford	Piedmont	Urban	15.1	9.2	4.8	9.4	8.4	417.2	0.020
Halifax	Eastern	Rural	23.5	12.7	8.0	15.7	13.6	702.8	0.019
Harnett	Eastern	Rural	20.5	13.3	5.6	11.0	10.6	396.1	0.027
Haywood	Western	Rural	21.4	16.5	8.6	18.4	14.8	467.6	0.032
Henderson	Western	Rural	7.7	6.8	3.3	6.4	5.4	414.7	0.013
Hertford	Eastern	Rural	16.9	9.0	3.0	8.7	7.6	464.2	0.016
Hoke	Eastern	Rural	22.1	11.9	4.4	8.0	9.4	337.8	0.028
Hyde	Eastern	Rural	18.5	17.6	5.8	11.5	10.2	394.4	0.026
Iredell	Piedmont	Rural	11.9	7.6	5.7	10.2	8.5	517.1	0.016
Jackson	Western	Rural	14.5	14.2	4.4	9.7	8.4	423.1	0.020
Johnston	Eastern	Rural	18.7	10.2	5.4	11.2	9.9	473.4	0.021
Jones	Eastern	Rural	23.0	17.4	7.0	16.5	13.7	488.6	0.028
Lee	Piedmont	Rural	18.9	13.5	4.5	8.9	9.2	497.7	0.018
Lenoir	Eastern	Rural	15.0	8.5	7.3	9.4	9.3	638.9	0.015
Lincoln	Piedmont	Rural	9.5	8.9	3.6	9.4	7.2	473.5	0.015
Macon	Western	Rural	9.0	4.6	3.7	5.5	5.1	423.0	0.012
Madison	Western	Rural	15.1	13.9	7.5	13.3	11.3	258.9	0.044
Martin	Eastern	Rural	5.9	4.8	4.2	5.1	4.8	602.5	0.008
Mcdowell	Western	Rural	11.8	7.7	3.8	9.2	7.3	545.9	0.013
Mecklenburg	Piedmont	Urban	11.2	7.3	4.8	8.4	7.3	358.3	0.020
Mitchell	Western	Rural	5.5	7.5	1.0	3.9	3.3	543.6	0.006
Montgomery	Piedmont	Rural	11.5	4.7	4.1	5.9	5.7	677.9	0.008
Moore	Piedmont	Rural	16.5	11.5	4.3	9.4	8.4	506.6	0.017
Nash	Eastern	Rural	17.0	11.2	3.8	6.8	7.5	533.5	0.014
New Hanover	Eastern	Urban	11.4	8.3	5.2	8.9	7.7	398.4	0.019
Northampton	Eastern	Rural	16.5	14.9	7.8	12.2	11.3	594.1	0.019
Onslow	Eastern	Rural	7.2	4.3	2.4	7.8	5.1	294.5	0.017
Orange	Piedmont	Urban	12.2	7.3	2.7	4.8	4.9	237.2	0.021
Pamlico	Eastern	Rural	24.7	24.1	4.5	9.7	10.1	323.7	0.031
Pasquotank	Eastern	Rural	55.0	35.8	9.4	18.2	21.0	524.0	0.040
Pender	Eastern	Rural	5.7	3.9	2.1	3.8	3.3	393.4	0.008
Perquimans	Eastern	Rural	37.9	21.3	7.2	10.6	13.1	460.6	0.028
Person	Piedmont	Rural	24.4	20.9	6.3	13.0	12.7	553.8	0.023
Pitt	Eastern	Rural	10.7	6.7	4.3	6.0	6.0	350.7	0.017
Polk	Western	Rural	2.8	2.3	1.2	2.5	2.0	362.6	0.006
Randolph	Piedmont	Rural	7.4	5.0	2.8	5.7	4.7	399.4	0.012
Richmond	Piedmont	Rural	8.4	7.1	6.1	10.2	8.1	835.8	0.010
Robeson	Eastern	Rural	38.1	23.6	11.0	22.1	20.8	681.4	0.030
Rockingham	Piedmont	Rural	16.9	10.1	5.9	11.2	9.8	611.8	0.016
Rowan	Piedmont	Urban	12.3	8.9	5.3	9.7	8.3	487.1	0.017
Rutherford	Western	Rural	11.5	10.5	8.9	16.7	12.5	635.6	0.020
Sampson	Eastern	Rural	25.7	18.2	8.3	18.8	15.8	521.2	0.030
Scotland	Eastern	Rural	16.6	9.1	8.2	9.2	9.9	596.8	0.017
Stanly	Piedmont	Rural	10.9	4.9	4.9	9.7	7.5	510.6	0.015
Stokes	Piedmont	Rural	9.1	7.0	2.6	5.1	4.8	492.0	0.010
Surry	Western	Rural	9.9	5.9	2.8	5.7	5.1	582.1	0.009
Swain	Western	Rural	15.2	20.3	7.4	13.5	12.3	672.3	0.018
Transylvania	Western	Rural	5.9	5.2	1.9	6.1	4.4	546.9	0.008
Tyrrell	Eastern	Rural	20.3	5.1	6.1	12.1	9.6	324.0	0.029
Union	Piedmont	Rural	10.9	6.5	3.4	7.1	6.2	283.0	0.022
Vance	Piedmont	Rural	5.2	4.2	2.5	7.7	5.2	656.5	0.008
Wake	Piedmont	Urban	22.0	14.5	5.4	10.6	10.6	318.8	0.033
Warren	Piedmont	Rural	5.5	1.0	1.7	4.9	3.3	465.6	0.007
Washington	Eastern	Rural	4.9	3.8	1.7	2.1	2.5	180.5	0.014
Watauga	Western	Rural	5.2	5.8	2.1	4.7	3.7	270.7	0.014
Wayne	Eastern	Rural	18.6	12.4	9.2	13.7	12.6	453.9	0.028
Wilkes	Western	Rural	9.0	8.1	3.2	7.4	6.1	550.8	0.011
Wilson	Eastern	Rural	24.9	20.2	12.8	24.5	19.9	581.9	0.034
Yadkin	Piedmont	Rural	7.1	3.7	1.6	4.9	3.8	462.4	0.008
Yancey	Western	Rural	6.7	4.0	3.2	4.3	4.1	385.7	0.011

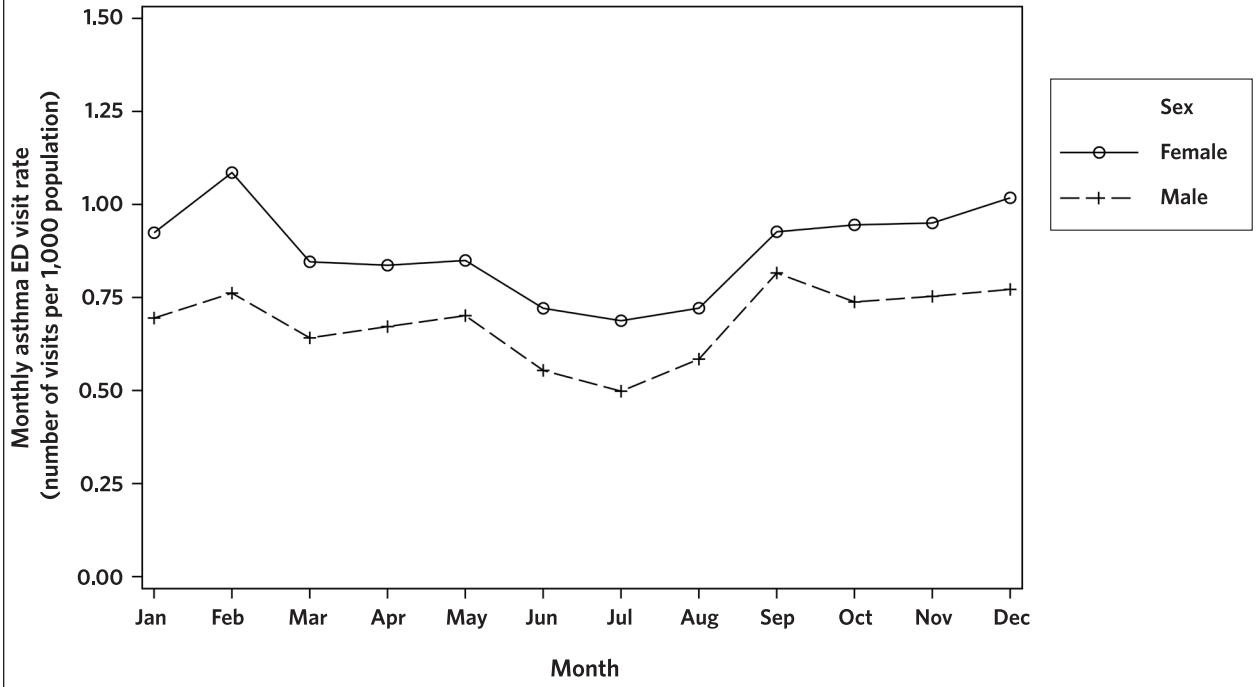
Note: ED visit rates are the number of ED visits per 1,000 population. Asthma ED visit rates include visits that had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis. Overall ED visit rates include all visits regardless of diagnosis.

TABLE 4.
Ranking of Counties by Asthma Emergency Department (ED) Visit Rate, Overall ED Visit Rate, and Ratio of Asthma ED Visit Rate to Overall ED Visit Rate

			Ranking by Asthma ED Visit Rate						
			Sex/age in yrs						
County	Region	Urban/Rural	M/<18	F/<18	M/≥18	F/≥18	Total population	Ranking by Overall ED visit rate	Ranking by ratio of asthma ED visit rate to overall ED visit rate
Pasquotank	Eastern	Rural	1	1	6	8	1	34	4
Robeson	Eastern	Rural	3	4	3	2	2	4	10
Wilson	Eastern	Rural	10	8	1	1	3	21	6
Anson	Piedmont	Rural	12	14	2	3	4	3	23
Cleveland	Piedmont	Rural	6	10	10	5	5	13	17
Cumberland	Eastern	Urban	2	2	42	19	6	78	2
Sampson	Eastern	Rural	8	12	13	6	7	35	11
Buncombe	Western	Urban	33	20	9	4	8	81	3
Haywood	Western	Rural	21	17	12	7	9	51	8
Craven	Eastern	Rural	13	11	20	9	10	27	19
Burke	Western	Rural	7	9	8	13	11	25	22
Jones	Eastern	Rural	17	15	22	11	12	42	14
Halifax	Eastern	Rural	16	31	15	12	13	2	39
Chowan	Eastern	Rural	5	28	5	25	14	16	27
Perquimans	Eastern	Rural	4	5	21	36	15	57	13
Edgecombe	Eastern	Rural	9	18	24	20	16	6	42
Person	Piedmont	Rural	14	6	26	21	17	26	25
Wayne	Eastern	Rural	28	36	7	14	18	58	16
Rutherford	Western	Rural	62	43	11	10	19	12	37
Swain	Western	Rural	45	7	18	15	20	7	51
Bertie	Eastern	Rural	31	46	4	30	21	8	54
Northampton	Eastern	Rural	40	19	16	22	22	19	43
Madison	Western	Rural	47	24	17	16	23	95	1
Beaufort	Eastern	Rural	39	25	25	18	24	15	46
Harnett	Eastern	Rural	22	29	34	32	25	72	18
Wake	Piedmont	Urban	19	22	38	35	26	87	7
Cabarrus	Piedmont	Urban	44	40	37	17	27	41	28
Hyde	Eastern	Rural	30	13	31	26	28	73	21
Columbus	Eastern	Rural	25	34	32	34	29	11	65
Caldwell	Western	Rural	20	30	36	33	30	23	53
Pamlico	Eastern	Rural	11	3	53	42	31	86	9
Bladen	Eastern	Rural	43	26	23	39	32	22	55
Johnston	Eastern	Rural	27	44	39	29	33	48	30
Scotland	Eastern	Rural	38	49	14	53	34	18	61
Rockingham	Piedmont	Rural	35	45	29	27	35	14	66
Catawba	Piedmont	Urban	52	32	30	28	36	44	33
Tyrrell	Eastern	Rural	24	81	28	23	37	85	12
Dare	Eastern	Rural	29	41	40	31	38	75	24
Hoke	Eastern	Rural	18	37	55	63	39	83	15
Alamance	Piedmont	Urban	23	33	56	40	40	62	29
Lenoir	Eastern	Rural	48	56	19	49	41	10	70
Lee	Piedmont	Rural	26	27	52	57	42	39	49
Franklin	Piedmont	Rural	37	42	51	46	43	60	41
Davidson	Piedmont	Urban	55	60	62	24	44	59	44
Forsyth	Piedmont	Urban	49	50	44	41	45	63	34
Iredell	Piedmont	Rural	59	64	33	38	46	36	64
Moore	Piedmont	Rural	41	38	58	48	47	38	60
Jackson	Western	Rural	50	23	54	45	48	64	36
Guilford	Piedmont	Urban	46	48	47	47	49	66	35
Currituck	Eastern	Rural	32	35	65	55	50	98	5
Rowan	Piedmont	Urban	57	52	41	43	51	43	58
Duplin	Eastern	Rural	42	61	49	54	52	54	52
Richmond	Piedmont	Rural	81	69	27	37	53	1	85
Alexander	Piedmont	Rural	71	55	35	52	54	46	62
Durham	Piedmont	Urban	54	57	50	58	55	68	38
New Hanover	Eastern	Urban	64	58	43	56	56	71	40
Camden	Eastern	Rural	15	16	95	70	57	91	20
Hertford	Eastern	Rural	36	51	75	59	58	53	63
Graham	Western	Rural	74	21	59	61	59	61	59
Nash	Eastern	Rural	34	39	63	72	60	32	71
Stanly	Piedmont	Rural	68	83	46	44	61	37	69
Granville	Piedmont	Rural	53	77	45	60	62	69	45
Mecklenburg	Piedmont	Urban	65	67	48	62	63	80	32
Mcdowell	Western	Rural	60	62	64	51	64	30	76
Lincoln	Piedmont	Rural	77	53	69	50	65	47	68
Gaston	Piedmont	Urban	70	76	66	67	66	45	77
Brunswick	Eastern	Rural	51	54	72	71	67	56	74
Union	Piedmont	Rural	67	75	70	69	68	92	26
Cherokee	Western	Rural	56	74	68	73	69	77	67
Greene	Eastern	Rural	75	47	81	66	70	84	50
Wilkes	Western	Rural	79	59	74	68	71	28	83
Pitt	Eastern	Rural	69	73	57	78	72	82	57
Montgomery	Piedmont	Rural	63	85	61	79	73	5	88
Carteret	Eastern	Rural	66	63	76	77	74	49	81
Henderson	Western	Rural	82	71	71	75	75	67	78
Caswell	Piedmont	Rural	72	89	78	74	76	93	47
Vance	Piedmont	Rural	94	90	83	65	77	9	94
Surry	Western	Rural	73	78	77	81	78	20	87
Macon	Western	Rural	80	86	67	83	79	65	79
Onslow	Eastern	Rural	84	88	85	64	80	89	56
Orange	Piedmont	Urban	58	68	80	88	81	96	31
Martin	Eastern	Rural	89	84	60	84	82	17	92
Stokes	Piedmont	Rural	78	70	82	85	83	40	86
Randolph	Piedmont	Rural	83	82	79	82	84	70	80
Transylvania	Western	Rural	88	80	89	76	85	29	93
Ashe	Western	Rural	61	72	84	92	86	24	95
Chatham	Piedmont	Rural	76	65	86	94	87	88	72
Yancey	Western	Rural	86	91	73	90	88	76	84
Yadkin	Piedmont	Rural	85	94	93	87	89	55	91
Gates	Eastern	Rural	98	96	94	80	90	99	48
Watauga	Western	Rural	93	79	87	89	91	94	75
Pender	Eastern	Rural	90	92	88	95	92	74	89
Davie	Piedmont	Rural	96	87	91	91	93	90	82
Warren	Piedmont	Rural	91	100	92	86	94	52	96
Mitchell	Western	Rural	92	66	100	93	95	31	97
Avery	Western	Rural	87	97	99	96	96	50	98
Washington	Eastern	Rural	95	93	90	100	97	100	73
Alleghany	Western	Rural	97	95	98	99	98	33	100
Polk	Western	Rural	100	98	96	97	99	79	99
Clay	Western	Rural	99	99	97	98	100	97	90

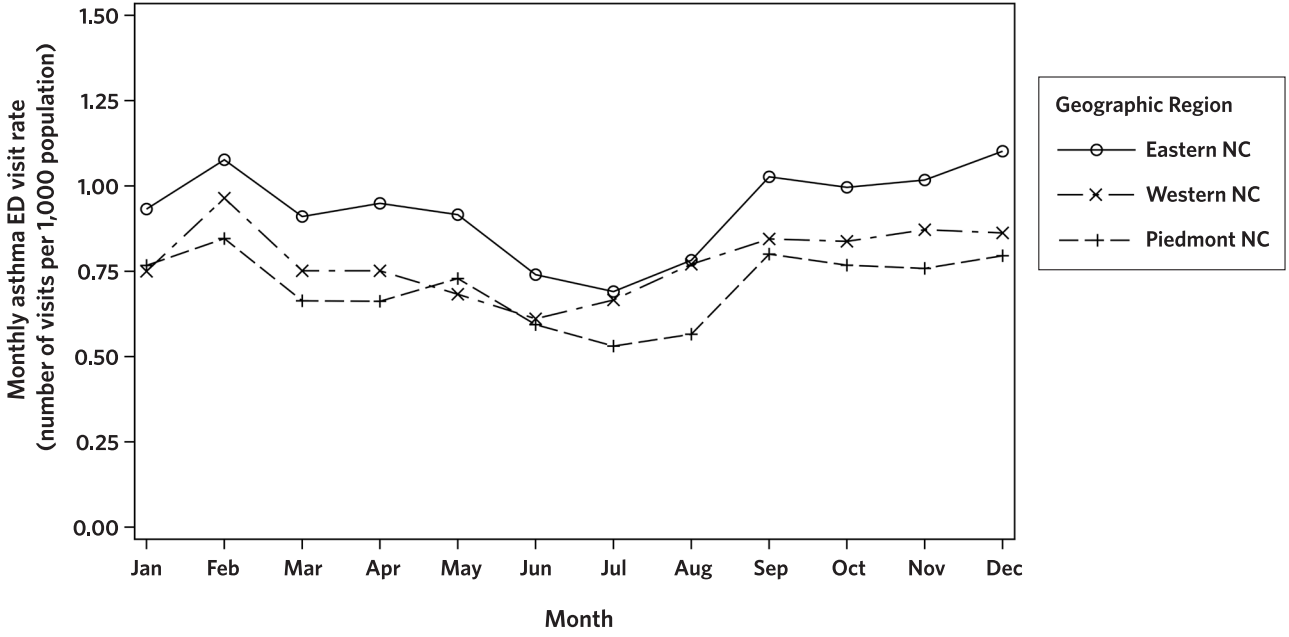
Note: ED visit rates are the number of ED visits per 1,000 population; the actual rates can be found in Table 2. Here, in each column, a rank of 1 indicates the highest ED visit rate in the state and a rank of 100 the lowest ED visit rate. Asthma ED visit rates include visits had an ICD-9-CM code of 493.00–493.99 as the first or second diagnosis. Overall ED visit rates include all visits regardless of diagnosis.

FIGURE 3.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Sex



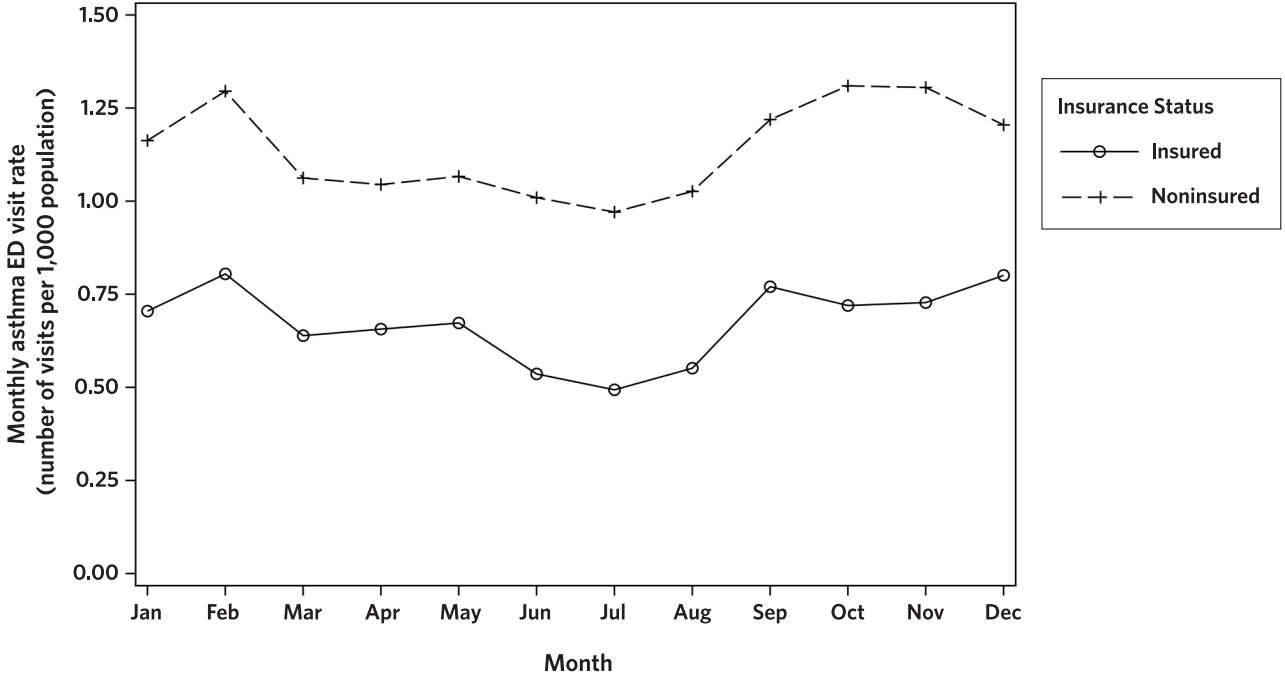
Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

FIGURE 4.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Region



Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.

FIGURE 5.
Monthly Asthma Emergency Department (ED) Visit Rates in North Carolina in 2008, by Insurance Status



Note: Asthma ED visits are those that had an ICD-9-CM code 493.00–493.99 as the first or second diagnosis.