

Children's Emergency Department Use for Asthma, 2001–2010

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The authors declare that they have no conflict of interest.

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ABSTRACT

OBJECTIVES: Although the emergency department (ED) provides essential care for severely ill or injured children, past research has shown that children often visit the ED for potentially preventable illnesses, including asthma. We sought to determine how children's rate of ED visits for asthma has changed over the last decade and to analyze what factors are associated with a child's potentially preventable ED visit for asthma.

METHODS: We retrospectively analyzed ED visits by children aged 2 to 17 from 2001 to 2010 using data from the National Hospital Ambulatory Medical Care Survey. Visits were classified as potentially preventable asthma visits by mapping ICD-9-CM diagnosis codes to the Agency for Healthcare Research and Quality's asthma pediatric quality indicator. We examined trends in the annual rate of ED visits for asthma per 1000 children using a weighted linear regression model. Finally, we used multivariate logistic regression to determine what demographic,

clinical, and structural factors were associated with a child's ED visit being for a potentially preventable asthma crisis.

RESULTS: The rate of children's ED visits for asthma increased 13.3% between 2001 and 2010, from 8.2 to 9.3 visits per 1000 children ($P = .26$). ED visits by children who were younger, male, racial or ethnic minorities, insured with Medicaid/Children's Health Insurance Program, and visiting between 11 PM and 7 AM were more likely to be for potentially preventable asthma crises.

CONCLUSIONS: Although the overall rate of potentially preventable ED visits for asthma did not significantly change over the last decade, racial, insurance-based, and other demographic disparities in the likelihood of a preventable asthma-related ED visit persist.

KEYWORDS: asthma; emergency department utilization; National Hospital Ambulatory Medical Care Survey

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WHAT'S NEW

Emergency department (ED) visits between 2001 and 2010 by children traditionally vulnerable to poor health care access were more likely to be for potentially preventable asthma crises than ED visits by their demographic counterparts, suggesting room for improvements in asthma care delivery.

IN 2011, 19% of all US children had at least 1 visit to the emergency department (ED), amounting to a total of 25 million ED visits by children annually.^{1,2} Although the ED represents an essential point of health care access for severely ill or injured children, many children seek treatment in the ED for potentially preventable reasons.³

Because of the high cost of ED care and the strained emergency care system, recent focus has been directed toward reducing ED visits that could have been either treated in a primary care setting or prevented by improved access to and quality of primary care.^{4,5} Children, who account for 1 in 5 ED visits nationally, have not been immune to these efforts.² One condition often highlighted as a driver of preventable ED use is childhood asthma. Asthma can be effectively managed by medication and high-quality primary

care,⁶ but it can also quickly escalate into a respiratory crisis requiring emergency care if not controlled.⁷

ED visits for asthma are often used as an adverse outcome for studies of the effectiveness of different asthma control therapies and practices,^{7–9} as well as those looking at the influence on the environment on children's asthma.^{10,11} However, studies of trends in and predictors of ED visits for asthma as measures of public health or the effectiveness of preventive care at the population level have mainly been limited to cross-sectional,¹² purely descriptive,^{13,14} or more dated analyses.^{15,16}

In the last decade, numerous initiatives and promising advances have been made in efforts to reduce asthma crises and associated preventable acute care use. The National Asthma Education and Prevention Program (NAEPP) of the National Institutes of Health's National Heart, Lung, and Blood Institute updated guidelines in 1997 and 2007 with scientific evidence describing diagnostic and treatment guidelines for physicians, including long-term strategies for monitoring and controlling asthma and preventing complications.¹⁷ There have been federally funded efforts to introduce initiatives to reduce ED visits for asthma, ranging from school asthma control programs to widespread dissemination of evidence-based guidelines.^{18,19} There have also been extensive state and local efforts to

increase preventive medication use for asthma²⁰ and reduce acute care use.⁹

To see whether these efforts have made an impact on preventable outpatient acute care use, we analyzed the trends in ED visits by children for asthma from 2001 to 2010. We also sought to identify the demographic, clinical, and structural characteristics associated with pediatric ED visits for potentially preventable asthma crises over this time period. The trajectory of and factors associated with children's ED use for asthma can help identify trends in children's access to and quality of preventive asthma care and can help target areas to reduce these potentially preventable ED visits.

METHODS

STUDY DESIGN AND DATA SOURCES

We conducted a retrospective analysis of hospital ED visits by children using data from the 2001–2010 National Hospital Ambulatory Medical Care Survey (NHAMCS). NHAMCS is a survey of ambulatory care visits to nonfederal, general, short-stay US hospitals conducted annually by the National Center for Health Statistics (NCHS). To generate a national probability sample of ED visits, NHAMCS uses a 3-stage sampling design: 112 geographic primary sampling units, approximately 480 hospitals within primary sampling units, and patient visits within EDs at each hospital.^{21,22}

For each sampled visit, US Census Bureau field representatives or hospital staff complete a patient record form on the basis of the patient's medical record. The data collected includes demographic information as well as clinical variables such as vital signs, cause of injury, diagnoses, medications, and discharge status. SRA International Inc (Durham, NC) performed the data processing. A 10% sample is independently coded for quality assurance; typical error rates found from the resulting comparison are 0.3% to 0.9%.

The survey data were analyzed using sampled visit weights provided by NCHS. The weights are the product of the sampling fractions at each stage of the design, and they take into account nonresponse rates within geographic region, time of year, demographic oversampling, and urban/rural and ownership designations. The final weighted visit counts represent national estimates of ED visits and associated characteristics. When computing rates of ED use per population, we used corresponding population denominator numbers from the US Census Bureau.

The NCHS research ethics review board approves the NHAMCS annually. This study was exempt from review by the Committee on Human Research at the University of California, San Francisco, because only deidentified data were used.

SAMPLE SELECTION

We included all ED visits by children 17 years and under. Within this group, we excluded children covered by Medicare (4.5%), as they are typically severely ill and disabled and their ED use is therefore not comparable to our remaining

sample. To limit the range of the clinical severity of visits, we also excluded patients who died in the ED (0.01%). Finally, per the specifications of the potentially preventable asthma measure of the Agency for Healthcare Research Quality (AHRQ), we excluded patients younger than 2 years old.

OUTCOME

Our primary outcome was ED visits by children with a principal ICD-9-CM diagnosis code for asthma, as specified in the AHRQ asthma pediatric prevention quality indicator.²³ Although the measure was primarily intended to measure preventable hospitalizations for asthma, the corresponding adult asthma measure has been used with ED visits in the past.^{24,25} In addition, similar categorizations of asthma diagnoses have been used as a measure of preventable asthma crises requiring acute care in previous studies.^{13,26}

COVARIATES

We defined numerous demographic and clinical visit characteristics that could be associated with a child's ED visit for asthma *a priori*, based largely on previous literature.^{12,27} We examined demographics including patient age (2 to 5, 6 to 9, 10 to 13, and 14 to 17 years old), insurance coverage (private, Medicaid/Children's Health Insurance Program [CHIP], self-pay/uninsured, and other), sex, and race (non-Hispanic white, non-Hispanic black, Hispanic, and other).^{12,28} We also examined basic visit characteristics including arrival method (ambulance, walk-in), arrival day (weekend, weekday), arrival time (7 AM to 3 PM, 3 PM to 11 PM, 11 PM to 7 AM), whether the patient was discharged from the hospital within the previous 7 days, and whether the patient had been seen at that ED in the last 72 hours. In addition, we examined clinical variables including triage level (need to be seen in less than 15 minutes, 15 minutes to 1 hour, 1 to 2 hours, and 2 to 24 hours, which corresponds to immediate/emergent, urgent, semiurgent, and nonurgent classifications) as determined by a triage nurse, and if the patient had any abnormal vital signs (pulse rate, blood pressure, temperature, or respiratory rate) given their age.^{29–31} Finally, we included the hospital's geographic region (Northeast, Midwest, South, West) and whether the hospital was in a urban or rural metropolitan statistical area.

STATISTICAL ANALYSIS

Using denominators from the US Census Bureau, we computed annual rates of ED visits for asthma per 1000 US children aged 2 to 17 and examined trends in the rates descriptively. We then analyzed the change in pediatric ED visit rates for asthma from 2001 to 2010 using a linear regression model weighted for population. Finally, we analyzed the association of the previously described demographic and structural factors with pediatric ED visits for asthma using a multivariate logistic regression model, which also incorporated NHAMCS sampling weights. Analyses were performed by SAS, version 9.2 (SAS Institute, Cary, NC), and SUDAAN, version 10.0 (RTI International, Research Triangle Park, NC).

RESULTS

We analyzed 62,849 pediatric ED visits between 2001 and 2010, representing 211 million visits nationally. Just under 3% of the visits were for potentially preventable asthma crises, with the weighted annual count rising 16% from 531,374 visits for asthma in 2001 to 615,958 in 2010. However, when adjusted for population, there was no significant trend in the rate of ED visits for asthma per 1000 children ages 2 to 17 from 2001 to 2010 ($P = .26$). Although the absolute change from 2001 to 2010 was 13.3%, there were significant fluctuations year to year, and no definitive direction was noted upon analysis with weighted linear regression (Figure). Similarly, the rate of ED visits for nonasthma diagnoses also exhibited no significant trend between 2001 and 2010 ($P = .16$).

As shown in Table 1, in an unadjusted descriptive comparison, visits for asthma were more likely to be by younger and male patients, racial or ethnic minorities, children with Medicaid insurance, children visiting from 11 PM to 7 AM, and children seen at urban hospitals compared to nonasthma visits. Children presenting with asthma were also more often admitted and had shorter triage times compared to those visiting the ED for another condition.

Our multivariate logistic regression showed that numerous demographic and clinical visit characteristics increased the odds that a visit was for a potentially preventable asthma crisis, even after adjustment for other influential factors (Table 2). For instance, ED visits by younger children and boys were more likely to be for potentially preventable asthma crises, as were visits by black and Hispanic children compared to white children. In addition, visits by children covered by Medicaid/CHIP had higher odds of being for potentially preventable asthma concerns than visits by privately insured children. Finally, pediatric ED visits with shorter triage times, visits at urban hospitals, visits occurring between 11 PM and 7 AM, and visits resulting in admission all had higher odds of being for a potentially preventable asthma crisis.

DISCUSSION

Over the last decade, we found that minority race, Medicaid insurance, younger age, and arrival between 11 PM and 7 AM were associated with increased odds of an ED visit being for a potentially preventable asthma crisis. Rural residence and female sex, on the other hand, were associated with decreased odds of an ED visit being for a potentially preventable asthma crisis. These results provide updated evidence that disparities continue to persist in access to quality preventive asthma care and preventable acute care use for asthma.

Our findings align with previous literature detailing the higher self-reported rates of ED visits for asthma among black,³² Hispanic,³³ and younger children.¹⁶ They also correspond with previous studies showing higher overall ED visits by children with Medicaid insurance,²⁵ as well as lower health care use for asthma by girls,¹⁶ but they stand in contrast to the evidence on worse primary care access for preventive asthma care in rural areas.³⁴

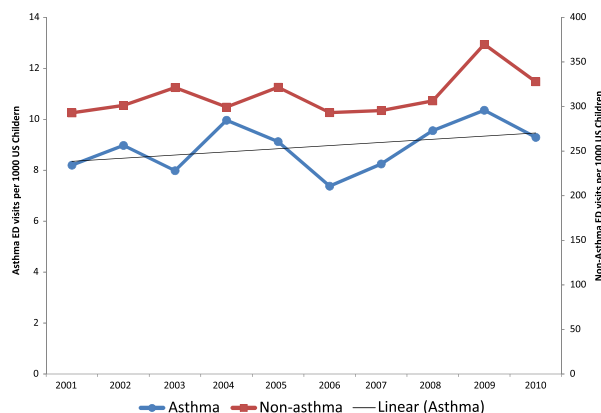


Figure. Rates of ED visits for potentially preventable asthma and non-potentially preventable asthma diagnoses by children aged 2 to 17 during 2001–2010. Although ED visit rates for potentially preventable asthma diagnoses (blue line) rose from 8.2 per 1000 children in 2001 to 9.3 per 1000 in 2010 (13.3%) and other diagnoses (red line) rose from 293 to 323 per 1000 (11.9%), there were many fluctuations, and neither was statistically significant ($P = .26$ and $.16$, respectively).

Many of the demographic groups that we find have higher odds of an ED visit being for potentially preventable asthma crises have higher prevalence of asthma, including racial minorities,³² boys,¹⁶ children in urban areas,³⁴ and low-income children likely to qualify for Medicaid,¹⁴ which likely drives a portion of the higher likelihood of potentially preventable ED visits for asthma.

However, our finding that ED visits by otherwise similar children between 11 PM and 7 AM had higher odds of being for potentially preventable asthma crises than visits occurring during the day suggests that these visits are related to a lack of primary care access, as most physician offices and clinics are closed during these hours. Past research has found that lack of after-hours access to primary care is a consistent driver of ED use,³⁵ and that better self- or parent-reported after-hours access to care is associated with lower ED use by children and adults.^{36,37} This evidence suggests continued room for improved asthma care delivery in the primary care setting to reduce potentially preventable acute care use, especially among vulnerable demographic groups.

We also found that visits during 3 PM to 11 PM, during which time many primary care clinics are closed at least a portion of the time, were significantly less likely to be for asthma than those between 7 AM and 3 PM. This discrepancy could be due to other factors, including slightly extended hours by many clinics and potentially the limited availability of urgent care centers.

Overall, the rate of ED use by children ages 2 to 17 for asthma rose from 8.2 visits per 1000 US children in 2001 to 9.3 visits per 1000 in 2010, but the change was not statistically significant and involved many fluctuations over the decade. A number of factors may have contributed to the generally stable trend. For instance, despite an increase in the prevalence of asthma in children, from 8.7% in 2001 to 9.4% in 2010,^{38,39} the numerous initiatives and promising advances to reduce asthma

Table 1. Characteristics of Pediatric Emergency Department Visits by Asthma Classification, 2001–2010

Characteristic	Asthma	No Asthma	P
	No. of Visits (col%)	No. of Visits (col%)	
Total	5,841,628 (100%)	205,232,589 (100%)	
Age			
2–5 y	2,189,485 (37.5%)	68,221,554 (33.2%)	<.01
6–9 y	1,534,378 (26.3%)	41,849,082 (20.4%)	
10–13 y	1,093,068 (18.7%)	40,619,837 (19.8%)	
14–17 y	1,023,697 (17.5%)	54,542,116 (26.6%)	
Sex			
Female	2,321,433 (39.7%)	97,888,803 (47.7%)	<.01
Male	3,520,195 (60.3%)	107,343,786 (52.3%)	
Race			
NH white	2,287,741 (39.2%)	116,309,200 (56.7%)	<.01
NH black	2,208,561 (37.8%)	45,987,147 (22.4%)	
Hispanic	1,172,623 (20.1%)	36,548,807 (17.8%)	
Other	172,703 (3.0%)	6,387,435 (3.1%)	
Geographic region			
Northeast	1,297,980 (22.2%)	36,502,022 (17.8%)	<.01
Midwest	1,415,000 (24.2%)	47,145,755 (23.0%)	
South	2,320,729 (39.7%)	86,059,909 (41.9%)	
West	807,919 (13.8%)	35,524,903 (17.3%)	
MSA			
Urban	5,218,664 (89.3%)	170,167,814 (82.9%)	<.01
Rural	622,964 (10.7%)	35,064,775 (17.1%)	
Insurance			
Private	2,143,936 (36.7%)	88,055,285 (42.9%)	<.01
Medicaid/CHIP	2,621,898 (44.9%)	78,519,895 (38.7%)	
Self-pay/uninsured	566,043 (9.7%)	19,640,080 (9.6%)	
Other	180,931 (3.1%)	7,058,809 (3.4%)	
Missing	328,820 (5.6%)	10,958,520 (5.3%)	
Arrival			
Ambulance	117,958 (2.0%)	2,844,930 (1.4%)	.29
Walk-in	1,076,776 (18.4%)	40,972,632 (20.0%)	
Unknown	4,646,894 (79.5%)	161,415,027 (78.6%)	
Arrival time			
7 AM–3 PM	2,041,342 (34.9%)	68,148,287 (33.2%)	<.01
3 PM–11 PM	2,424,912 (41.5%)	107,944,134 (52.6%)	
11 PM–7 AM	1,334,589 (22.8%)	27,214,840 (13.3%)	
Unknown	40,785 (0.7%)	1,925,328 (0.9%)	
Triage			
<15 min	1,236,284 (21.2%)	21,978,909 (10.7%)	<.01
15 min to 1 h	2,511,213 (43.0%)	68,325,771 (33.3%)	
1–2 h	1,019,028 (17.4%)	58,182,384 (28.3%)	
2–24 h	266,361 (4.6%)	25,584,006 (12.5%)	
Unknown	808,742 (13.8%)	31,161,519 (15.2%)	
Arrival day			
Weekend	1,886,067 (32.3%)	63,103,434 (30.7%)	.36
Weekday	3,955,561 (67.7%)	142,129,155 (69.3%)	
Discharged within 7 d			
Yes	35,216 (0.6%)	1,454,745 (0.7%)	.52
No	2,135,931 (36.6%)	78,874,421 (38.4%)	
Unknown	3,670,481 (62.8%)	124,903,421 (38.4%)	
Seen before			
Yes	112,275 (1.9%)	4,527,958 (2.2%)	.65
No	4,922,905 (84.3%)	173,743,578 (84.7%)	
Unknown	806,448 (13.8%)	26,961,053 (13.1%)	
Abnormal vital signs*			
Any abnormal	240,260 (4.1%)	10,443,419 (5.1%)	.21
All normal	5,124,216 (87.7%)	176,126,614 (85.8%)	
Any missing	477,152 (8.2%)	12,662,556 (9.1%)	

(Continued)

Table 1. Continued

Characteristic	Asthma	No Asthma	P
	No. of Visits (col%)	No. of Visits (col%)	
Discharge status			
Transfer	79,405 (1.4%)	2,922,524 (1.4%)	<.01
Admitted to hospital	431,009 (7.4%)	6,452,480 (3.1%)	
Discharged/left	5,291,277 (90.6%)	193,591,559 (94.4%)	
Unknown	39,937 (0.7%)	2,215,299 (1.1%)	

NH indicates non-Hispanic; MSA, metropolitan statistical area; CHIP, Children's Health Insurance Program.

*The range of normal for breaths per minute is 22 to 34 for those 2 to 5 years old, 18–30 for those 6 to 12 years old, and 12–16 for those older than 12 years. The range of normal for heart beats per minute is 80 to 140 for those 2 to 5 years old, 70 to 120 for those 6 to 12 years old, and 60 to 100 for those older than 12 years. The range of normal systolic blood pressure is 70 to 95 mm Hg for children 2 to 8 years old, and 90 to 140 mm Hg for those older than 8 years. Values that fell outside (above or below) these ranges were considered abnormal. Abnormal temperature was defined as a recorded temperature above 38°C/100.4°F.^{29,30}

crises and associated preventable acute care use in this past decade may have had some effect. For example, in 1999 the US Centers for Disease Control and Prevention launched the National Asthma Control Program, which invested over \$238 million between 2001 and 2012 in territorial and state asthma control programs, school asthma control programs, national surveillance, and developing and disseminating best practices and evidence-based guidelines.¹⁸ This huge effort was adapted locally in all states and implemented with different partners and stakeholders,⁴⁰ and it could have potentially affected the trajectory of potentially preventable ED visits for asthma.

In addition, environmental and behavioral trends during our study period, including improvements in air quality⁴¹ and decreasing smoking prevalence,⁴² should have reduced the prevalence of asthma triggers and the associated number of preventable asthma crises and ED visits. Finally, from 2001 to 2010, the proportion of children with private insurance dropped from 70% to 60%, while the proportion of children covered by Medicaid and CHIP/State Health Insurance Program for Children programs rose from 23% to 36%.⁴³ Given overwhelming evidence that children with Medicaid have more difficulty accessing high-quality primary care than privately insured children,^{37,44,45} and perhaps the resulting evidence of their higher rate of potentially preventable ED use,^{25,46} this population-level insurance transition may have driven up the rate of ED use for potentially preventable asthma crises over time.

LIMITATIONS

There are several limitations to our study. First, because there is no linkage between visits in NHAMCS, we could not identify multiple visits by the same child. Therefore, our results only reflect rates of ED visits per 1000 children, not the proportion of the population with an ED visit.

Table 2. Results of Multivariate Logistic Regression Model of Factors Associated With Potentially Preventable Emergency Department Visits for Asthma by Children Aged 2 to 17, 2001–2010

Characteristic	Adjusted OR (95% CI)
Age	
2–5 y	Reference
6–9 y	1.2 (1.1, 1.4)
10–13 y	0.9 (0.8, 1.1)
14–17 y	0.6 (0.5, 0.7)
Sex	
Female	0.7 (0.6, 0.8)
Male	Reference
Race	
NH white	Reference
NH black	2.2 (1.9, 2.6)
Hispanic	1.4 (1.2, 1.7)
Other	1.2 (0.8, 1.7)
Geographic region	
Northeast	1.5 (1.2, 1.9)
Midwest	1.4 (1.1, 1.8)
South	1.1 (0.9, 1.4)
West	Reference
MSA	
Urban	Reference
Rural	0.7 (0.5, 0.9)
Insurance	
Private	Reference
Medicaid/CHIP	1.2 (1.1, 1.4)
Self-pay/uninsured	1.2 (0.9, 1.5)
Other	1.0 (0.6, 1.7)
Missing	1.1 (0.8, 1.5)
Arrival	
Ambulance	1.0 (0.6, 1.7)
Walk-in	Reference
Unknown	0.9 (0.8, 1.5)
Arrival time	
7 AM–3 PM	Reference
3 PM–11 PM	0.8 (0.7, 0.9)
11 PM–7 AM	1.6 (1.3, 1.9)
Unknown	0.8 (0.4, 1.4)
Triage	
<15 min	5.5 (3.8, 7.8)
15 min to 1 h	3.6 (2.6, 5.1)
1–2 h	1.7 (1.2, 2.5)
2–24 h	Reference
Unknown	2.5 (1.7, 3.7)
Arrival day	
Weekend	1.1 (0.9, 1.3)
Weekday	Reference
Discharged within 7 d	
Yes	0.6 (0.3, 1.4)
No	Reference
Unknown	1.0 (0.9, 1.2)
Seen before	
Yes	0.9 (0.6, 1.4)
No	Reference
Unknown	1.0 (0.9, 1.3)
Abnormal vital signs	
Any abnormal	0.9 (0.6, 1.3)
All normal	Reference
Any missing	0.9 (0.7, 1.2)
Discharge status	
Transfer	0.8 (0.5, 1.5)
Admitted to hospital	1.9 (1.5, 2.4)
Discharged*	Reference
Unknown	0.6 (0.3, 1.3)

NH indicates non-Hispanic; MSA, metropolitan statistical area; CHIP, Children's Health Insurance Program.

*Includes left without being seen.

Second, as with all administrative data, there are limitations in the accuracy and ability to verify clinical data as a result of a combination of chart abstraction and keying errors.⁴⁷ However, there is no other nationally representative data set that allows an analysis over this length of time to be performed. Because the purpose of this study was to present trends reflecting changes in the ability of the pediatric primary care system to prevent the need for ED use, we think it is an appropriate use of the data.

CONCLUSIONS

Although the overall rate of potentially preventable ED visits for asthma by children did not change significantly between 2001 and 2010, ED visits by younger children, boys, racial minorities, those enrolled in Medicaid/CHIP programs, and those visiting between the hours of 11 PM and 7 AM had higher odds of being for potentially preventable asthma crises. Our findings that populations vulnerable to poor health care access continue to be the most likely to make preventable ED visits for asthma potentially suggest that efforts to decrease barriers to quality preventive care for asthma may be more effective when targeted more specifically at certain subpopulations.

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