

Asthma outcomes in children and adolescents with multiple morbidities: Findings from the National Health Interview Survey

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Background: More Americans are managing multiple chronic conditions (MCCs), and trends are particularly alarming in youth.

Objective: The purpose of this study was to examine the prevalence and distribution of 9 chronic conditions in children and adolescents with and without asthma, and adverse asthma outcomes associated with having MCCs.

Methods: Cross-sectional interview data from the National Health Interview Survey were analyzed (N = 66,790) between 2007 and 2012 in youth 0 to 17 years of age. Bivariate analysis methods and multivariate generalized linear regression were used to examine associations.

Results: Five percent of children with asthma had 1 or more coexisting health conditions. The prevalence of 1 or more comorbidities was greater among those with asthma than those without (5.07% [95% CI: 4.5-5.6] vs 2.73% [95% CI: 2.6-2.9]). Those with asthma were twice as likely to have co-occurring hypertension (prevalence ratio [PR] = 2.2 [95% CI: 1.5-3.2]) and arthritis (PR = 2.7 [95% CI: 1.8-4.0]) compared with those without asthma. Every additional chronic condition with asthma was associated with a greater likelihood of an asthma attack (PR = 1.1 [95% CI: 1.0-1.2]), all-cause emergency department visits (PR = 1.3 [95% CI: 1.1-1.5]), and missed school days (PR = 2.3 [95% CI: 1.7-3.2]).

Conclusions: Children and adolescents with asthma in the US who suffer from MCCs have increased asthma symptoms, missed school days, and all-cause emergency department visits. Further research on optimal management strategies for this group is needed. (J Allergy Clin Immunol 2014;■■■:■■■-■■■.)

Key words: Outcomes, comorbidity, epidemiology, asthma, pediatrics

Chronic diseases affect 1 in 2 adults in the US, and alarming trends show that 1 in 4 of all adults are now managing multiple chronic conditions (MCCs), defined as 2 or more chronic health

Abbreviations used

BMI: Body mass index
ED: Emergency department
MCCs: Multiple chronic conditions
NHIS: National Health Interview Survey
PR: Prevalence ratio

conditions that affect a person at the same time.¹ Trends are concerning in youth, with 26% of US children managing a chronic condition, and 1 in 15 now managing MCCs.^{2,3} MCCs have profound effects on cognitive, emotional, and social development, increasing expenditures for health care and disability programs, and put youth at substantially greater risk for decreased work force participation, educational opportunities, and quality of life.⁴ Children with multiple chronic medical conditions have higher rates of readmission after illness episodes,⁵ have been shown to seek a majority of their care in the emergency department (ED),⁶ and account for a large proportion of health care expenditures.⁷

Estimates from the National Health Interview Survey (NHIS) from the 1980s reveal that MCCs are most prominent in youth who are older, male, of white race, and non-poor, and those with atopic conditions.⁴ Since the 1980s, chronic diseases in children have risen by nearly 10%. As a result, current population trends may be different and shifting, and a better understanding of where to target support efforts may be timely.

Asthma is the most common chronic condition evident in children (9.5%, 7.1 million)⁸ and is the main reason children use urgent care services for a chronic disease.⁹ Asthma is among the top 10 conditions with the highest prevalence of readmission rates among children.¹⁰ It is a condition also marked by significant disparities.⁸ In adults, national estimates suggest that more than half of adults with asthma have 1 or more coexisting health conditions, and adverse outcomes are evident.¹¹ Whether similar trends are evident in children with asthma is unknown. Such information may better inform clinical and community support efforts to assist families in managing asthma in the presence of other chronic conditions.

This study analyzed recent data from the NHIS¹² to 1) compare the prevalence of 9 chronic conditions evident in children and adolescents with and without asthma and 2) assess the extent to which comorbid conditions are associated with adverse asthma outcomes.

METHODS

Data source

The NHIS is a cross-sectional household interview survey that examines a nationally representative sample each year of about 35,000 civilian,

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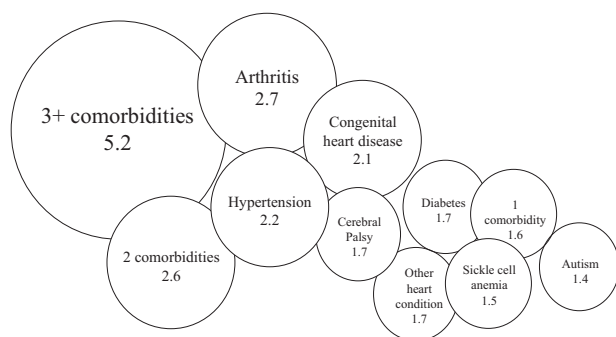


FIG 1. PR of the associations between asthma and other chronic conditions in US children and adolescents, adjusted for age, sex, race, and socioeconomic status.

noninstitutionalized households that comprise 90,000 individuals from 35,000 families.¹² NHIS uses a complex, multistage area probability sample design that permits the representative sampling of households and noninstitutional group quarters.¹² Details of the multistage sampling strategy of NHIS are described elsewhere.¹² Select groups such as African Americans, Hispanics, and Asians are oversampled in order to increase the reliability of their health status estimates. From each family in the NHIS, 1 sample adult and 1 sample child are randomly selected, and information on each is collected with the Sample Adult Core and the Sample Child Core questionnaires. Interviews are conducted using computer-assisted personal interviewing mode. Written informed consent and assent are collected from all participating families.

Analytic sample

Six years (2007 to 2012) of NHIS survey data were pooled for the current analysis in order to increase sample size and the statistical reliability of estimates. The analytic sample includes only children 0 to 17 years of age. The overall unweighted interview response rate was 88.4% ($n = 9,417$) in 2007, 85.6% ($n = 8,815$) in 2008, 89.9% ($n = 11,156$) in 2009, 89.8% ($n = 11,277$) in 2010, 91.8% ($n = 12,850$) in 2011, and 90.7% ($n = 13,275$) in 2012. The final unweighted sample comprised 66,790 individuals interviewed between 2007 and 2012. Of this group, 6,350 individuals were identified as having asthma, based on positive responses to the following questions: “Has a doctor or health professional ever told you that your child has asthma?” and “Does the child still have asthma?”

In addition to asthma, parents were asked if a doctor had ever told them that their child had any of the following chronic conditions: cerebral palsy, muscular dystrophy, sickle cell anemia, autism, diabetes, arthritis, congenital heart disease, other heart condition, or hypertension. These conditions were chosen due to the availability of data on chronic health conditions in the data source in each survey cycle that was pooled and met the following definition of a chronic health condition as cited by other work in children: a health condition that lasts ≥ 12 months or at time of diagnosis is likely to have a duration of ≥ 12 months.⁴ The conditions available in the NHIS were determined for inclusion based on US Department of Health and Human Services recommendations for standardized reporting of common conditions.¹³ For this paper, an aggregate measure of chronic conditions for children was created using the following groupings: 0, 1, 2, or ≥ 3 . MCCs in this paper refer to having asthma and 1 or more other chronic conditions.

Measures

Outcomes investigated included ED visits due to asthma, all-cause ED visits, asthma attacks, and missed school days all assessed over the past year. These outcomes give indication of the level of a child's asthma control.¹⁴ *ED visits*: “During the past 12 months, did the child have to visit an emergency room or urgent care center because of {his/her} asthma?” assessed ED visits specific to asthma, while the item “During the past 12 months, how many times has the child gone to a hospital or emergency room about his/her

health?” assessed ED visits related to the child's overall health. *Asthma symptom episodes*: “During the past 12 months, has the child had an episode of asthma or an asthma attack?” assessed symptoms related to asthma, specifically exacerbations. *Missed school days*: “During the past 12 months, about how many days did the child miss school because of illness or injury?” assessed missed school days. Socioeconomic status in this study was defined as poverty (income to needs ratio < 2) or above poverty level (ratio ≥ 2). The basis for estimating financial needs based on family size was adapted from the literature¹⁵ and relates needs to income, meaning that those whose income is less than 2 times their financial needs are considered to be in poverty.

Analyses were computed in SAS (v.9.3) and SUDAAN (V11.1). SAS survey and SUDAAN procedures were used to adjust for the NHIS complex sample design. The data were weighted using the full sample 1-year health interview weight for NHIS. Since 6 years of data were combined for this analysis, each cycle-specific case weight was divided by 6, which produced a scaled weight across all 6 years that summed to the US population on average across the 6-year period.¹² Missing data were ignored, given that less than 10% of missing data were observed on variables in the analysis. Statistical significance was assigned based on a Type 1 error level of $\alpha = .05$ or 95% CI for estimates of population statistics.

The weighted prevalence of each chronic condition and mean of number of chronic conditions in the US population with and without asthma were analyzed and compared using SAS Proc SurveyFreq and Proc Survey Means. Multivariate Poisson regression (log link, Poisson pseudo likelihood) using the SUDAAN Proc Loglink procedure was used to estimate the prevalence ratios (PR; relative risk) for asthma diagnosis comparing persons with/without each chronic condition. Consistent with the complex sample design of NHIS, the Taylor Series Linearization method was used to compute robust estimates for the Poisson regression coefficients and CIs for the corresponding PR estimates.

The weighted prevalence of demographic and clinical characteristics, and adverse asthma outcomes (asthma attacks, missed school days, ED visits due to asthma, all-cause ED visits) in the US population with asthma only and asthma with comorbidity were estimated using SAS 9.3 survey procedures. This analysis was stratified by children 0 to 11 years of age, and adolescents 12 to 17 years of age. Note that body mass index (BMI) was only available for adolescents aged 12 to 17 years. Estimates were compared using a Student t test or χ^2 tests of independence with the Rao-Scott complex sample design adjustment.

Multivariate Poisson regression was also used to examine the number of comorbid chronic conditions predicting adverse asthma outcomes. This analysis was stratified by children 0 to 11 years of age and adolescents 12 to 17 years of age. Models were estimated in SUDAAN with Taylor Series variance estimation to capture the complex sample design. All models were estimated using the NHIS analysis weight and were adjusted for age, sex, race, and socioeconomic status. For adolescents, models were additionally adjusted for BMI.

RESULTS

Ten percent ($n = 6,350$) of children and adolescents between 0 and 17 years of age in the national sample reported continued presence of physician-diagnosed asthma, and 5% of children with asthma reported having 1 or more comorbidities. Weighted estimates of demographic characteristics of the sample stratified by individuals with and without asthma are presented in [Table I](#). A high percentage of children with asthma were in households who met federal guidelines for poverty (50.5%; [95% CI: 48.9-52.1]). Children with asthma were older on average than those without asthma (9.7 years [95% CI: 9.6-9.8] vs 8.5 years [95% CI: 8.4-8.6]; $P < .001$) and included a higher percentage of individuals who were male (56.8% [95% CI: 55.6-58.1] vs 50.7% [95% CI: 50.3-51.1]; $P < .001$) and African American (28.6% [95% CI: 27.3-30.0] vs 15.9% [95% CI: 15.3-16.5]; $P < .001$). A greater proportion of the asthma group reported at

TABLE I. Demographic and clinical characteristics of children and adolescents in the US population with and without asthma

	Total (n = 66,790)	No asthma (n = 60,298)†	Asthma (n = 6,350)‡	χ^2 or <i>t</i> test, <i>P</i> value
Age, y (mean)	8.6 [8.5 to 8.7]	8.5 [8.4 to 8.6]	9.7 [9.6 to 9.8]	<i>t</i> = 18.1***
Male	51.3 [50.9 to 51.7]	50.7 [50.3 to 51.1]	56.8 [55.6 to 58.1]	χ^2 (1) = 89.2***
Race/ethnicity				χ^2 (5) = 718.8***
White	70.7 [70.0 to 71.4]	71.9 [71.2 to 72.6]	59.8 [58.4 to 61.2]	
Black/African American	17.1 [16.5 to 17.7]	15.9 [15.3 to 16.5]	28.6 [27.3 to 30.0]	
American Indian and Alaska Native	1.2 [1.0 to 1.5]	1.2 [1.0 to 1.5]	1.2 [0.9 to 1.5]	
Asian	6.2 [5.8 to 6.5]	6.4 [6.1 to 6.7]	4.0 [3.5 to 4.4]	
Other	0.2 [0.2 to 0.3]	0.2 [0.2 to 0.3]	0.3 [0.1 to 0.4]	
Multiple race	4.6 [4.4 to 4.8]	4.4 [4.2 to 4.6]	6.0 [5.4 to 6.8]	
Income-to-needs ratio				χ^2 (1) = 86.4***
Poverty	44.2 [43.3 to 45.0]	43.5 [42.6 to 44.3]	50.5 [48.9 to 52.1]	
Above poverty	55.8 [55.0 to 56.7]	56.5 [55.7 to 57.4]	49.5 [47.9 to 51.1]	
Other chronic conditions with asthma				χ^2 (1) = 111.6§***
0	96.9 [96.8 to 97.0]	97.2 [97.1 to 97.3]	94.44 [93.9 to 95.0]	
1	3.0 [2.8 to 3.1]	2.73 [2.6 to 2.9]	5.07 [4.5 to 5.6]	
2	0.09 [0.07 to 0.1]	0.067 [0.04 to 0.09]	0.41 [0.3 to 0.6]	
3	0.01 [0 to 0.02]	0.003 [0 to 0.008]	0.08 [0.01 to 0.1]	

Estimates are % and 95% CI.

P* < .05, *P* < .01, ****P* < .001.

†Parents who answered “Refused” or “Don’t know” were excluded from the analysis.

‡This is the number of children who still have asthma.

§Due to low cell count, the χ^2 test only compares the 0 and 1 categories.**TABLE II.** Weighted prevalence rates and adjusted PR of the associations between asthma and other chronic conditions in US children and adolescents

Chronic conditions	No asthma (n = 60,298)	Asthma (n = 6,350)	Adjusted PR†
Cerebral palsy	0.4 [0.4 to 0.5]	0.9 [0.6 to 1.1]	1.7 [1.3 to 2.1]***
Muscular dystrophy	0.003 [0 to 0.008]	—	—
Sickle cell anemia	0.2 [0.1 to 0.2]	0.5 [0.3 to 0.7]	1.5 [1.1 to 2.1]*
Autism	0.9 [0.8 to 1.0]	1.5 [1.2 to 1.8]	1.4 [1.2 to 1.7]***
Diabetes	0.2 [0.1 to 0.2]	0.4 [0.2 to 0.6]	1.7 [1.1 to 2.4]**
Arthritis	0.07 [0.05 to 0.1]	0.3 [0.2 to 0.4]	2.7 [1.8 to 4.0]***
Congenital heart disease	0.2 [0.1 to 0.2]	0.5 [0.3 to 0.7]	2.1 [1.5 to 3.0]***
Other heart condition	0.9 [0.8 to 0.9]	1.7 [1.4 to 2.0]	1.7 [1.4 to 2.1]***
Hypertension	0.8 [0.6 to 1.0]	2.3 [1.4 to 3.3]	2.2 [1.5 to 3.2]***
Asthma + 1 other condition	2.7 [2.6 to 2.9]	5.1 [4.5 to 5.6]	1.6 [1.4 to 1.8]***
Asthma + 2 other conditions	0.07 [0.04 to 0.09]	0.4 [0.3 to 0.6]	2.6 [1.8 to 3.7]***
Asthma + ≥3 other conditions	0.003 [0 to 0.008]	0.08 [0.01 to 0.1]	5.2 [3.5 to 7.8]***

Estimates are % and 95% CI.

— No observation under this criterion.

P* < .05, *P* < .01, ****P* < .001.

†Models adjusted for age, sex, race, and socioeconomic status.

least 1 other chronic condition compared with the non-asthma group (5.07% [95% CI: 4.5-5.6] vs 2.73% [95% CI: 2.6-2.9]; *P* < .001).

Table II shows the weighted proportions of the 9 selected chronic conditions in individuals with and without asthma. Comparing children with and without each of these conditions, Table II and Fig 1 also show the adjusted PR for asthma. Adjusting for age, sex, race, and socioeconomic status, the likelihood of an asthma diagnosis was significant for each of the 9 chronic conditions in this study, but it was most exacting for hypertension (PR = 2.2 [95% CI: 1.5-3.2]) and arthritis (PR = 2.7 [95% CI: 1.8-4.0]).

Table III shows the weighted prevalence of youth characteristics and adverse outcomes with asthma with and without comorbidity, stratified by children 0 to 11 years of age and adolescents 12 to 17 years of age. Compared with children with

only asthma, a greater proportion of children with asthma and other chronic conditions were male (70% [95% CI: 63.7-76.4] vs 58.5 [95% CI: 57.0-60.0]; *P* < .01) and experienced an asthma attack (64.3% [95% CI: 57.7-70.8] vs 57.5% [95% CI: 56.0-59.1]; *P* < .05), asthma-related ED visit (36% [95% CI: 27.5-44.5] vs 26.7% [95% CI: 24.8-28.7]; *P* < .05), and more missed school days due to asthma (53.4% [95% CI: 46.3-60.5] vs 40% [95% CI: 38.5-41.6]; *P* < .001). Among adolescents, a greater proportion with asthma and other chronic conditions were male (63.7% [55.8-71.6] vs 52.8% [50.7-55.0]; *P* < .01), living in households meeting federal guidelines for poverty (53.3% [95% CI: 45.4-61.2] vs 44.2% [95% CI: 41.9-46.5]; *P* < .05), obese (40.5% [95% CI: 31.8-49.2] vs 26.1% [95% CI: 24.2-28.0]; *P* < .01), and experienced an asthma attack (61% [95% CI: 53.0-68.9] vs 47% [95% CI: 44.9-49.0]; *P* < .001), all-cause ED visit over the past 12 months (39.9% [95% CI: 31.8-47.9] vs 27.8%

TABLE III. Weighted prevalence of demographic and clinical characteristics and functional impairment over the past 12 months in children and adolescents with asthma (n = 6,347) with and without comorbidity

Variable	Children (0-11 y) (n = 3,800)			Adolescents (12-17 y) (n = 2,547)		
	Asthma only (n = 3,593)	Asthma and comorbidity (n = 207)	χ^2 or t, P value	Asthma only (n = 2,401)	Asthma and comorbidity (n = 146)	χ^2 or t, P value
Male	58.5 [57.0 to 60.0]	70.0 [63.7 to 76.4]	$\chi^2(1) = 10.41^{**}$	52.8 [50.7 to 55.0]	63.7 [55.8 to 71.6]	$\chi^2(1) = 6.62^{**}$
Income-to-needs ratio			$\chi^2(1) = 1.97$, NS			$\chi^2(1) = 5.04^*$
Poverty	54.0 [52.0 to 56.1]	59.2 [52.2 to 66.2]		44.2 [41.9 to 46.5]	53.3 [45.4 to 61.2]	
Above poverty	46.0 [43.9 to 48.0]	40.8 [33.8 to 47.9]		55.8 [53.5 to 58.1]	46.7 [38.8 to 54.6]	
Race/Ethnicity			$\chi^2(3) = 4.25$, NS†			$\chi^2(2) = 3.29$, NS†
White	57.4 [55.6 to 59.3]	51.2 [43.7 to 58.7]		64.2 [62.3 to 66.1]	58.2 [50.8 to 65.7]	
Black/African American	30.2 [28.4 to 32.0]	32.4 [25.7 to 39.0]		25.9 [24.2 to 27.7]	30.1 [22.6 to 37.7]	
American Indian/Alaska Native	1.2 [0.8 to 1.6]	1.9 [0.03 to 3.8]		1.0 [0.6 to 1.4]	2.8 [0.1 to 5.4]	
Asian	4.2 [3.7 to 4.9]	4.3 [1.6 to 7.1]		3.6 [3.0 to 4.2]	1.4 [0 to 3.3]	
Other	0.3 [0.2 to 0.5]	0.5 [0 to 1.4]		0.1 [0 to 0.3]	—	
Multiple race	6.5 [5.7 to 7.4]	9.7 [3.4 to 14.0]		5.1 [4.2 to 6.1]	7.5 [3.4 to 11.7]	
BMI percentile‡	—	—				$\chi^2(2) = 12.30^{**}$
Healthy weight	—	—		55.3 [53.4 to 57.2]	45.5 [36.4 to 54.5]	
Overweight	—	—		18.6 [16.8 to 20.3]	14.0 [8.1 to 20.0]	
Obesity	—	—		26.1 [24.2 to 28.0]	40.5 [31.8 to 49.2]	
Asthma attacks	57.5 [56.0 to 59.1]	64.3 [57.7 to 70.8]	$\chi^2(1) = 3.70^*$	47.0 [44.9 to 49.0]	61.0 [53.0 to 68.9]	$\chi^2(1) = 11.03^{***}$
ED visit for asthma	26.7 [24.8 to 28.7]	36.0 [27.5 to 44.5]	$\chi^2(1) = 5.02^*$	12.9 [11.23 to 14.5]	15.9 [8.3 to 23.4]	$\chi^2(1) = 0.69$, NS
Missed school days (mean)	5.0 [4.8 to 5.3]	12.4 [8.4 to 16.5]	t = 27.54***	5.7 [5.3 to 6.2]	9.6 [6.5 to 12.8]	t = 2.64**
All-cause ED visit	40.0 [38.5 to 41.6]	53.4 [46.3 to 60.5]	$\chi^2(1) = 13.66^{***}$	27.8 [26.1 to 29.5]	39.9 [31.8 to 47.9]	$\chi^2(1) = 9.77^{**}$

— No observation under this criterion.

Estimates are % and 95% CI.

* $P < .05$, ** $P < .01$, *** $P < .001$.

NS, Not significant.

†Due to low cell count, the χ^2 test compares the difference between white, black/African American, and multiple race categories only.

‡BMI data only available for adolescents.

TABLE IV. Adjusted multivariate regression models of number of comorbid chronic conditions predicting adverse outcomes among children and adolescents with asthma (n = 6,347)

Adverse asthma outcomes in last 12 mo	Children (0-11 y) (n = 3,800)	Adolescents (12-17 y) (n = 2,547)
	Adjusted PR [95% CI] for adverse outcomes per additional comorbid chronic condition	Adjusted PR [95% CI] for adverse outcomes per additional comorbid chronic condition†
Asthma attack	1.1 [1.00 to 1.2]*	1.2 [1.0 to 1.4]*
ED visit due to asthma	1.5 [1.2 to 1.8]***	1.2 [0.8 to 1.7]
Missed school days	2.3 [1.7 to 3.2]***	1.5 [1.2 to 2.0]**
All-cause ED visit	1.3 [1.1 to 1.5]***	1.4 [1.1 to 1.7]**

Models adjusted for age, sex, race, and socioeconomic status.

* $P < .05$, ** $P < .01$, *** $P < .001$.

†Models additionally adjusted for BMI.

[95% CI: 26.1-29.5]; $P < .01$), as well as more missed school days due to asthma (9.6% [95% CI: 6.5-12.8] vs 5.7% [95% CI: 5.3-6.2]; $P < .01$) compared with adolescents with only asthma.

Table IV shows the results of the likelihood of adverse asthma outcomes with every additional chronic condition with asthma stratified by children and adolescents. For children 0 to 11 years of age, every additional chronic condition with asthma was associated with a greater likelihood of an asthma attack (PR = 1.1 [95% CI: 1.0-1.2]; $P < .05$), all-cause ED visit (PR = 1.3 [95% CI: 1.1-1.5]; $P < .001$), missed school days (PR = 2.3 [95% CI: 1.7-3.2]; $P < .001$), and asthma-specific ED visits (PR = 1.5 [95% CI: 1.2-1.8]; $P < .01$). Similar results were seen in adolescents 12 to 17 years of age, except for the relationship between additional comorbid chronic conditions and asthma-related ED visits.

DISCUSSION

A proportion of children with asthma in the US have co-occurring chronic conditions, and this group experiences worse asthma-related health outcomes and more all-cause ED visits compared with children with asthma only.

Six percent of children with asthma in the US have been diagnosed with at least 1 other major chronic nonrespiratory health condition, and prevalence is highest for comorbid hypertension and arthritis. Hypertension and arthritis have also been shown to be highly prevalent in adults with asthma.¹¹ Further, the high prevalence of hypertension with asthma confirms other work showing high rates of obesity-related risk factors and sequelae with asthma.¹⁶ Although BMI information was not available for the whole sample, a greater proportion of adolescents with asthma and MCC in this study were also

obese. Two recent systematic reviews examining the nature of association between obesity and asthma report that the few prospective studies available suggest that overweight and obesity may precede asthma and change the mechanical properties of the respiratory system.^{17,18} There may also be other physiologic causal connections between asthma and observed, co-occurring conditions that require further research. Airway anomalies or thoracic muscle weakness may exacerbate asthma or increase risk of developing other chronic conditions. Adolescents with hypertension and asthma had much higher BMIs than those with asthma only; thus, weight gain may potentially explain the hypertension/asthma association seen here. Prospective studies are needed to further delineate causality.

Trends have also shifted over the past 20 years,⁴ and MCCs in adolescents with asthma are more heavily concentrated in lower-income households. This may be due to similar risk factors that contribute to higher asthma prevalence in low-income families, and the development of other chronic conditions surveyed in this study.⁸ For example, low-income urban areas have been described as both breeding grounds for asthma triggers, as well as difficult environments to navigate healthy food options and physical activity.^{19,20} This trend may also be attributed to greater opportunities for diagnosis of chronic conditions as a result of expansion of the State Children's Health Insurance Program for youth in low-income households over the past 15 years.

This study found some evidence that children and adolescents with asthma and other conditions of interest had worse asthma-related outcomes. While the mechanisms explaining higher rates of adverse outcomes are unclear, it may be that self-management tasks compete between asthma and other conditions or become more complex and difficult to manage, symptom differentiation becomes more difficult, or children with MCCs require more routine health services use, thus competing with school attendance. Barriers to effective self-care for adults with MCCs have been discussed and may be similar for children and adolescents, such as polypharmacy, physical limitations, and exacerbation of 1 condition by another or its treatment.^{21,22} Further, self-management responsibility for youth is often shifting beyond the family to include other caregivers and individuals in the school environment, and for adolescents, taking on greater independence with self-care. MCCs may complicate the coordination and developmental transition of self-management, given the magnified responsibility of self-care tasks beyond a single condition. High rates of health care spending and hospital readmission among children with complex medical needs in the general population provide further support of difficulties with self-management evident in the MCC population.^{5,7}

The findings from this study speculate that the trends seen in adults with asthma may start as early as childhood, since asthma persists to adulthood in at least 25% of children,²³ and the MCCs they develop early on may also follow. Current trends of MCCs in children with asthma and the state of the health-related infrastructure that they navigate to manage their overall health may have significant implications for their health status and psychosocial development into adulthood, including educational attainment, workforce participation, quality of life, and greater health care expenditures.

The management of MCCs in children is not well understood, given that families obtain community and health care services

around individual chronic diseases. Moreover, current treatment guidelines and training of health care providers focus on the prevention, management, and treatment of individual conditions with insufficient evidence to inform strategies that consider the co-occurrence of other chronic conditions. Programmatic elements of behavioral asthma interventions in particular, which target the management capacity of children and adolescents, are also typically centered exclusively around the management tasks related to asthma.²⁴ Studies that examine the common and unique features in MCC management in children and adolescents with asthma are indicated, and existing self-management interventions that have demonstrated improvements in outcomes may be adapted and tailored to the presence of co-occurring conditions.

More targeted research and intervention efforts are needed to ensure that children with MCCs are able to effectively manage all of their chronic conditions within their family and social context in order to lead a full and active life, and that care teams are equipped to adequately serve the complex needs of these individuals and families in the medical home model. The Affordable Care Act will promote greater use of medical homes. Medical homes have significant opportunities to coordinate and consolidate care for children and families with MCCs. MCC management in pediatric and adolescent care is particularly unique compared with that in adult care, given significant transitions in both health care service seeking and caregiving evident during these developmental periods. Given that MCCs transition into adulthood for many youth, further efforts to bolster health systems to seamlessly transition individuals requiring chronic care over the lifetime is a research priority.

There are several limitations to this study. We measured the prevalence of only 9 potential comorbidities with asthma, and others may be evident in combination with asthma that were not available in the data source. NHIS data are cross-sectional; therefore, the direction and mechanisms of causality between asthma-related adverse events and MCCs, as well as the mechanisms that may explain the onset of co-occurring conditions with asthma cannot be determined. Differences in care-seeking behavior may influence an underreported number of co-occurring chronic conditions in these data, as respondents may have avoided health screening that would lead to an established diagnosis. Given that some conditions are difficult to diagnose in younger children, MCCs may be evident in some of the sample children based on symptom experience, but lack an official diagnosis. Thus, the prevalence of asthma and MCCs in the general population may in fact be higher than reported here. BMI data were not available for youth under the age of 12; therefore, associations between asthma and MCCs and weight gain could not be observed in this group. Data on the costs of care among youth with asthma and MCC were also not available in the data source. Future studies should examine the relative health care costs this group incurs compared to the general population of youth with MCC. Lastly, as in all health surveys, errors in recall may have affected respondent reports. However, survey items reflect queries often used by clinicians in determining the presence of disease in their patients.

MCCs are evident in children and adolescents with asthma. The subgroup of patients with co-occurring conditions with asthma appears to be vulnerable to adverse outcomes. Research efforts are warranted, as are efforts to enable families and social structures through counseling and education to manage asthma in youth effectively in conjunction with their other chronic

conditions. Immediately, clinical care teams may be aware of extra supportive resources that families may need to manage and coordinate the care of their children with asthma and MCC.

Key messages

- US children with asthma are 1.6 times more likely to manage other co-occurring conditions compared with children without asthma.
- Obesity-related sequelae are high among children with asthma.
- More chronic conditions with asthma are associated with greater likelihood of adverse health events.

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