RESEARCH ARTICLE

Risk Factors for Prolonged Length of Stay or Complications During Pediatric Respiratory Hospitalizations

Sunitha V. Kaiser, MD, MSc,[a] Leigh-Anne Bakel, MD, MSc,[b] Megumi J. Okumura, MD, MAS,[a] Andrew D. Auerbach, MD, MPH,[c] Jennifer Rosenthal, MD,[a] Michael D. Cabana, MD, MPH[a,d,e]

ABSTRACT

BACKGROUND AND OBJECTIVES: Respiratory illnesses are the leading cause of pediatric hospitalizations in the United States, and a major focus of efforts to improve quality of care. Understanding factors associated with poor outcomes will allow better targeting of interventions for improving care. The objective of this study was to identify patient and hospital factors associated with prolonged length of stay (LOS) or complications during pediatric hospitalizations for asthma or lower respiratory infection (LRI).

METHODS: Cross-sectional study of hospitalizations of patients <18 years with asthma or LRI (bronchiolitis, influenza, or pneumonia) by using the nationally representative 2012 Kids Inpatient Database. We used multivariable logistic regression models to identify factors associated with prolonged LOS (>90th percentile) or complications (noninvasive ventilation, mechanical ventilation, or death).

RESULTS: For asthma hospitalizations(n = 85 320), risks for both prolonged LOS and complications were increased with each year of age (adjusted odds ratio [AOR] 1.06, 95% confidence interval [CI] 1.05–1.07; AOR 1.05, 95% CI 1.03–1.07, respectively for each outcome) and in children with chronic conditions (AOR 4.87, 95% CI 4.15–5.70; AOR 21.20, 95% CI 15.20–29.57, respectively). For LRI hospitalizations (n = 204 950), risks for prolonged LOS and complications were decreased with each year of age (AOR 0.98, 95% CI 0.97–0.98; AOR 0.95, 95% CI 0.94–0.96, respectively) and increased in children with chronic conditions (AOR 9.86, 95% CI 9.03–10.76; AOR 56.22, 95% CI 46.60–67.82, respectively). Risks for prolonged LOS for asthma were increased in large hospitals (AOR 1.67, 95% CI 1.32–2.11) and urban-teaching hospitals (AOR 1.62, 95% CI 1.33–1.97).

CONCLUSIONS: Older children with asthma, younger children with LRI, children with chronic conditions, and those hospitalized in large urban-teaching hospitals are more vulnerable to prolonged LOS and complications. Future research and policy efforts should evaluate and support interventions to improve outcomes for these high-risk groups (eg, hospital-based care coordination for children with chronic conditions).

[a]Departments of Pediatrics, [c]Medicine, and [d]Epidemiology and Biostatistics, and [e]Phillip R. Lee Institute for Health Policy Studies, University of California, San Francisco, San Francisco, California; and [b]Department of Paediatrics, Hospital for Sick Children, Toronto, Ontario, Canada

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Address correspondence to Sunitha Kaiser, MD, MSc, Department of Pediatrics, University of California San Francisco, 550 16th St, 5th Fl, Box 0110, San Francisco, CA 94158. E-mail: Sunitha.Kaiser@ucsf.edu

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Respiratory illnesses are the leading cause of pediatric hospitalizations in the United States, causing nearly 25% of hospitalizations.[1] In 2006, there were ~200 000 hospitalizations of children for pneumonia and asthma costing ~$2 billion.[2] Due to the tremendous burden of respiratory illnesses in children, they have been the main focus of national efforts to measure and improve quality of health care. In 2007, the Joint Commission implemented metrics to enable tracking of quality of care for children hospitalized with asthma,[3] and more recently, the National Quality Forum developed a quality metric focused on readmissions of children after hospitalization for lower respiratory infections (LRIs), including bronchiolitis, pneumonia, and influenza.[4] At the hospital level, many institutions have implemented interventions such as clinical pathways or practice guidelines to improve care for children hospitalized for respiratory illnesses.[5–9] However, such interventions require substantial commitment of resources toward development, implementation, and maintenance.[10] Ideally, interventions to improve care should be targeted toward high-risk patients or hospitals.

Our goal was to identify patient- and hospital-level factors associated with prolonged length of stay (LOS) or complications during pediatric hospitalizations for respiratory illnesses, by using a nationally representative sample. Previous analyses with similar aims have been limited to single hospitals.[11,12] We hypothesized that patient-level characteristics (eg, race, insurance status) and hospital-level characteristics (eg, bed size, region) may affect LOS or complications in patients with asthma or LRIs. The information we gain from this national analysis can be used by physicians, hospital administrators, and policy makers to better target limited resources to improve outcomes for children hospitalized with these common conditions.

METHODS

Data Source and Study Design

We performed a cross-sectional analysis of the most recent year of the Kids

TABLE 1 Characteristics of Pediatric Hospitalizations for Asthma and LRI

Characteristic	Asthma, Weighted, *n* = 85 320	LRI, weighted, *n* = 204 950
Age, mean (SE), y	6.52 (0.03)	2.33 (0.02)
Median (SE), y	5.11 (0.05)	0.31 (0.01)
Gender, *n* (%)		
Girls	32 561 (38.2)	90 695 (44.3)
Boys	52 759 (61.8)	114 248 (55.7)
Race, *n* (%)		
White	24 433 (28.6)	87 683 (42.8)
Black	30 331 (35.5)	34 281 (16.7)
Hispanic	18 428 (21.6)	50 176 (24.5)
Asian or Pacific Islander	2252 (2.6)	5569 (2.7)
Native American	645 (0.8)	2493 (1.2)
Unknown[a]	9231 (10.8)	24 749 (12.1)
Patient's residence,[b] *n* (%)		
Urban	70 844 (83.1)	149 588 (73.1)
Rural	14 381 (16.9)	55 072 (26.9)
Payment Source, *n* (%)		
Public insurance	51 271 (60.2)	124 134 (60.7)
Private insurance	28 345 (33.3)	68 344 (33.4)
Self-pay/no charge/other[c]	5531 (6.5)	11 878 (5.81)
Median household income quartile, *n* (%)		
Quartile 1	33 093 (40.0)	74 306 (37.1)
Quartile 2	19 073 (23.0)	49 457 (24.7)
Quartile 3	16 690 (20.2)	43 370 (21.6)
Quartile 4	13 934 (16.8)	33 239 (16.6)
No. of chronic conditions, *n* (%)		
0	0 (0)	119 494 (58.3)
1	66 662 (78.1)	55 879 (27.3)
2–4	17 528 (20.5)	23 093 (11.3)
>4	1130 (1.3)	6483 (3.2)
Discharge quarter, *n* (%)		
Jan–Mar	20 273 (23.8)	91 460 (44.6)
Apr–Jun	18 316 (21.5)	33 424 (16.3)
Jul–Sept	19 981 (23.4)	21 592 (10.5)
Oct–Dec	26 734 (31.3)	58 440 (28.5)
Hospital bed size, *n* (%)		
Small	10 722 (12.6)	24 660 (12.0)
Medium	20 752 (24.3)	49 340 (24.1)
Large	53 846 (63.1)	130 950 (63.9)
Hospital location and teaching status		
Rural	6399 (7.5)	27 063 (13.2)
Urban nonteaching	17 171 (20.1)	52 372 (25.6)
Urban teaching	61 750 (72.4)	125 515 (61.2)
Geographic region, *n* (%)		
Northeast	21 237 (24.9)	36 552 (17.8)
Midwest	16 383 (19.2)	42 709 (20.8)
South	31 051 (36.4)	81 868 (39.9)
West	16 649 (19.5)	43 821 (21.4)

TABLE 1 Continued

Characteristic	Asthma, Weighted, n = 85 320	LRI, weighted, n = 204 950
Control/ownership of hospital, n (%)		
Government nonfederal	11 328 (13.3)	25 554 (12.5)
Private nonprofit	62 959 (73.8)	150 241 (73.3)
Private investor-owned	11 033 (12.9)	29 154 (14.2)

[a] Due to a large number of missing values (>8%), the category "Other" and missing values were combined to create the "Unknown" category.
[b] Urban defined as counties with populations >250 000 residents.
[c] Due to small cell sizes, these categories were grouped.

Inpatient Database (KID), 2012. KID is developed by the Agency for Healthcare Research and Quality; it is the only all-payer hospital administrative dataset designed to assess use of hospital services by children.[13] KID includes a systematic random sample of pediatric discharges (age <21 years) from all hospitals in the 44 participating states (n = 4179). Discharge records contain de-identified, patient-level, clinical, and resource use data included in a typical discharge abstract.[13] The database provides discharge weights to extrapolate from sampled discharges and produce national estimates of discharges from all US, community, nonrehabilitation hospitals. A detailed report on estimate and variance generation is found in the statistical report provided by the Healthcare Cost and Utilization Project.[14]

Study Population

The analysis included all hospitalizations with a diagnosis of asthma or LRI as the primary diagnosis. Asthma was defined by using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes 493.0 to 493.92,[15] and LRI was defined by using ICD-9-CM codes specified by the National Quality Forum metric (Appendix).[4] Records without documented age were excluded.[4] Hospitalizations with transfer as the admission source or discharge disposition were excluded because of inability to accurately determine LOS.[15] Elective hospitalizations were excluded because of the possibility that these were for routine workup rather than acute treatment.[2] The analysis of children with asthma excluded hospitalizations of children <2 years because of the potential for overlap between bronchiolitis and a true diagnosis of asthma in this age group.[15]

Analysis

Comparisons of LOS and Rates of Complications

LOS and rates of complications were compared for each group, those with asthma and those with LRI. Complications included mechanical ventilation, noninvasive ventilation, or death; this outcome was created by using the Clinical Classifications Software code 216 for mechanical ventilation and ICD-9-CM procedure code 93.90 for noninvasive ventilation[16] (ventilation without use of an artificial airway, such as positive-pressure ventilation with nasal/face mask).[17] LOS and rates of complications were compared with respect to the patient-level characteristics age, gender, race, median household income quartile, patient's residence (urban versus rural), payment source, and number of chronic medical conditions, as well as the hospital-level characteristics size, location and teaching status, hospital ownership, and geographic region. These variables were chosen based on previous studies showing potential associations.[11,12,16,18–21] Discharge quarter was included to account for seasonal variation in respiratory hospitalizations.

Nearly 10% of values were missing for race, so these were labeled "Unknown" and collapsed with "Other," so the records would not be excluded from our analysis.[16] Continuous variables were categorized to allow univariate tests of comparison. Univariate tests for LOS were done by using simple linear regression. Univariate tests for rates of complications were done by using χ^2 tests.

Predictors of Prolonged LOS and Complications

Prolonged LOS was defined as the 90th percentile of the LOS distribution for each condition (asthma = 3.3 days, LRI = 5 days).[22] Multivariable logistic regression modeling was used to determine patient- and hospital-level characteristics associated with prolonged LOS or complications during hospitalization. Number of chronic conditions was included in the models to address confounding bias that may be caused by higher case-severity mix at certain types of hospitals. Chronic conditions were identified by using the Chronic Condition Indicator, developed by the Agency for Healthcare Research and Quality.[23] This indicator categorizes all ICD-9-CM diagnosis codes as chronic or not chronic and categorizes the condition within a body system (eg, circulatory system). A chronic condition is defined as a condition that lasts >12 months and (1) places limitations on self-care, independent living, and social interactions; or (2) results in the need for ongoing intervention with medical products, services, and special equipment. Examples include malignancies, diabetes, asthma, and congenital anomalies. Chronic conditions were modeled in 4 categories and as a continuous variable (in a sensitivity analysis). All variables with $P < .20$ in univariate analysis were included in the model.[24] Odds ratios with 95% confidence intervals (CIs) were determined for each predictor variable.

This study qualified for exempt status from the University of California, San Francisco, Committee on Human Research. All analyses were performed by using SAS 9.3 (SAS Institute, Inc, Cary, NC). Survey-weighted procedures were used for all descriptive statistics and regression models to account for the complex survey design.

RESULTS

Characteristics of pediatric hospitalizations for asthma and LRI are described in Table 1. There were 60 429 asthma hospitalizations and 144 569 LRI hospitalizations before survey-weighting. After survey-weights were applied, there were 85 320 asthma hospitalizations and 204 950 LRI

hospitalizations. All remaining results represent survey-weighted analyses.

For asthma hospitalizations, mean age was 6.52 (SE 0.03) years, with 62% of hospitalizations for boys. Most hospitalizations were of children with 1 chronic condition (78%) in the respiratory disorder category, so most likely represents asthma. Most hospitalizations were of children from lower median household income quartiles (40% in Quartile 1, 23% in Quartile 2), living in urban settings (83%), with public insurance as the payment source (60%). Most hospitalizations occurred in large (63%), urban-teaching (72%), private nonprofit hospitals (74%).

LRI hospitalizations included those for bronchiolitis (50%), pneumonia (46%), and influenza (4%). For LRI hospitalizations, mean age was younger at 2.33 (SE 0.02) years, with 56% of hospitalizations for boys. Most hospitalizations were of children with no chronic conditions (58%), from lower median household income quartiles (37% in Quartile 1, 25% in Quartile 2), living in urban settings (73%), with public insurance as the payment source (61%). Most occurred in large (64%), urban-teaching (61%), private nonprofit hospitals (73%).

LOS for pediatric asthma and LRI are described in Table 2. For asthma hospitalizations, LOS was longer in the older age group compared with the youngest and in those with public insurance compared with private insurance. Hospitalizations of children with >4 chronic conditions were over double the length of those for children with 1 chronic condition. For LRI hospitalizations, LOS was longer in the older age group compared with the youngest group, in Hispanic children compared with white children, and in those with public insurance compared with private insurance. Hospitalizations of children with >4 chronic conditions were more than 3 times longer than those with no chronic conditions.

Comparisons of rates of complications for pediatric asthma and LRI are described in Table 3. For pediatric asthma hospitalizations, a total of 1595 (1.9%) of hospitalizations indicated a complication: all

TABLE 2 LOS in Pediatric Hospitalizations for Asthma and LRI

Characteristic	LOS, mean (SE), d	
	Asthma, weighted, n = 85 320	LRI, weighted, n = 204 950
Overall	2.10 (0.03)	3.10 (0.04)
Age, y[a]		
<2	N/A[b]	3.03 (0.03)
2–4	1.93 (0.03)	2.83 (0.05)
5–11	2.14 (0.03)	3.13 (0.06)
12–17	2.43 (0.04)	4.47 (0.17)
Gender		
Girls	2.17 (0.03)	3.15 (0.04)
Boys	2.06 (0.03)	3.05 (0.04)
Race		
White	2.05 (0.03)	3.01 (0.04)
Black	2.16 (0.04)	2.98 (0.04)
Hispanic	2.18 (0.05)	3.30 (0.08)
Asian or Pacific Islander	2.03 (0.05)	3.22 (0.09)
Native American	2.14 (0.10)	3.06 (0.10)
Unknown[c]	2.06 (0.03)	3.14 (0.10)
Patient's residence[d]		
Urban	2.11 (0.02)	3.20 (0.05)
Rural	2.10 (0.03)	2.81 (0.04)
Payment source		
Public insurance	2.17 (0.03)	3.17 (0.05)
Private insurance	2.03 (0.03)	2.96 (0.04)
Self-pay/no charge/other[e]	2.06 (0.04)	3.10 (0.11)
Median household income quartile		
Quartile 1	2.13 (0.04)	3.11 (0.05)
Quartile 2	2.12 (0.04)	3.08 (0.05)
Quartile 3	2.10 (0.03)	3.14 (0.05)
Quartile 4	2.01 (0.03)	3.06 (0.05)
No. of chronic conditions		
0	N/A[b]	2.59 (0.02)
1	1.98 (0.03)	2.91 (0.03)
2–4	2.40 (0.04)	4.61 (0.09)
>4	4.60 (0.30)	8.61 (0.28)
Complicated stay[f]		
Yes	4.71 (0.29)	9.75 (0.27)
No	2.05 (0.03)	2.85 (0.03)
Discharge quarter		
Jan–Mar	2.22 (0.03)	3.12 (0.03)
Apr–Jun	2.06 (0.03)	3.31 (0.06)
Jul–Sept	2.01 (0.03)	3.13 (0.08)
Oct–Dec	2.11 (0.03)	2.93 (0.04)
Hospital bed size		
Small	1.85 (0.08)	2.83 (0.08)
Medium	2.13 (0.06)	2.98 (0.07)
Large	2.14 (0.03)	3.19 (0.06)

TABLE 2 Continued

Characteristic	LOS, mean (SE), d	
	Asthma, weighted, $n = 85\,320$	LRI, weighted, $n = 204\,950$
Hospital location and teaching status		
Rural	2.00 (0.02)	2.43 (0.03)
Urban nonteaching	2.14 (0.05)	2.74 (0.06)
Urban teaching	2.10 (0.04)	3.39 (0.06)
Geographic region		
Northeast	2.10 (0.07)	2.92 (0.09)
Midwest	2.01 (0.06)	3.09 (0.09)
South	2.15 (0.04)	3.08 (0.07)
West	2.11 (0.06)	3.27 (0.12)
Control/ownership of hospital		
Government nonfederal	2.20 (0.05)	2.89 (0.06)
Private nonprofit	2.09 (0.03)	3.17 (0.05)
Private investor-owned	2.10 (0.11)	2.90 (0.07)

[a] Age was categorized by using the National Heart, Lung, and Blood Institute EPR-3 guideline to allow for univariate tests of comparison.
[b] No hospitalizations in this category.
[c] Due to a large number of missing values (>8%), the category "Other" and missing values were combined to create the "Unknown" category.
[d] Urban defined as counties with populations >250 000 residents.
[e] Due to small cell sizes, these categories were grouped.
[f] Complicated stay defined as a hospitalization that involved noninvasive ventilation, mechanical ventilation, or death.

1595 (1.9%) indicated use of mechanical ventilation, 1109 (1.3%) indicated use of both noninvasive and mechanical ventilation, and 17 (0.02%) indicated use of mechanical ventilation and the complication death. Complication rates were higher in hospitalizations of older children ($P < .001$); black, Hispanic, and Asian children compared with white children ($P < .001$); and >20 times higher in hospitalizations of children with >4 chronic conditions (22%) compared with those with 1 condition (1%, $P < .001$). For pediatric LRI hospitalizations, a total of 7327 (3.6%) of hospitalizations indicated a complication: all 7327 (3.6%) indicated use of mechanical ventilation, 2664 (1.3%) indicated use of both noninvasive and mechanical ventilation, and 164 (0.08%) indicated use of mechanical ventilation and the complication death. Complication rates were higher in the oldest group ($P < .001$) and in Asian and Hispanic children compared with white children ($P < .001$). The complication rate in children with >4 chronic conditions was 40%, >30 times higher than in children with no chronic conditions (1.2%, $P < .001$). Complication rates for both asthma and LRI were higher during hospitalizations in large ($P < .001$), urban-teaching hospitals ($P < .001$).

Final results from our multivariable model are described in Table 4. The model controlled for the patient factors of age, gender, race, place of residence, payment source, discharge quarter, income quartile, and number of chronic conditions, and the hospital factors of size, location and teaching status, geographic region, and control/ownership (government, private nonprofit, or private investor-owned hospital). Among hospitalizations of children for asthma ($n = 82\,619$), odds of prolonged LOS ($n = 9969$) were increased with each year of age (adjusted odds ratio [AOR] 1.06, 95% CI 1.05–1.07). Hospitalizations of children with chronic medical conditions had significantly increased odds of prolonged LOS (AOR 4.87, 95% CI 4.15–5.70 for >4 conditions compared with 1 condition). Odds of prolonged LOS were higher in hospitalizations with public insurance compared with private insurance (AOR 1.13, 95% CI 1.06–1.21), in large hospitals (AOR 1.67, 95% CI 1.32–2.11]), and in urban-teaching hospitals compared with rural hospitals (AOR 1.62, 95% CI 1.33–1.97).

During hospitalizations for asthma, odds of complications ($n = 1071$) were also increased with each year of age (AOR 1.05, 95% CI 1.03–1.07). Odds of complications were increased during hospitalizations of black (AOR 1.35, 95% CI 1.11–1.66) or Asian (AOR 2.29, 95% CI 1.38–3.79) children compared with white children, and children with chronic medical conditions (AOR 21.20, 95% CI 15.20–29.57 for >4 conditions compared with 1 condition). Odds of complications were higher in hospitalizations with public insurance compared with private insurance (AOR 1.24, 95% CI 1.05–1.46), in large hospitals (AOR 1.67, 95% CI 1.03–2.73), and in urban-teaching hospitals compared with rural hospitals (AOR 4.07, 95% CI 2.25–7.36).

Among hospitalizations of children for LRI ($n = 199\,782$), after our multivariable model controlled for chronic medical conditions, the relationship between LOS and age was reversed, and we found odds of prolonged LOS ($n = 21\,825$) were decreased with each year of age (AOR 0.98, 95% CI 0.97–0.98). Odds were also decreased in hospitalizations of black children compared with white children (AOR 0.82, 95% CI 0.76–0.88). Hospitalizations of girls (AOR 1.13, 95% CI 1.10–1.17) and children with chronic medical conditions had significantly increased odds of prolonged LOS (AOR 9.86, 95% CI 9.03–10.76 for >4 conditions compared with no conditions). Odds of prolonged LOS were also higher in hospitalizations with public insurance compared with private insurance (AOR 1.14, 95% CI 1.09–1.19), in large hospitals (AOR 1.30, 95% CI 1.16–1.46), and in urban-teaching hospitals compared with rural hospitals (AOR 2.41, 95% CI 2.12–2.74).

After controlling for chronic conditions, the relationship between complications and age was also reversed, with odds of complications ($n = 5071$) decreased with each year of age (AOR 0.95, 95% CI 0.94–0.96). Odds of complications were increased in hospitalizations of girls (AOR

TABLE 3 Comparisons of Pediatric Hospitalizations for Asthma and LRIs With and Without Complications

Characteristic	Asthma			LRI		
	Complication, *n* (%), Weighted, *n* = 1595	No Complication, *n* (%), Weighted, *n* = 83 725	*P*[a]	Complication, *n* (%), Weighted, *n* = 7327	No Complication, *n* (%), Weighted, *n* = 197 623	*P*[a]
Age, y[b]						
<2	N/A[c]	N/A[c]	N/A[c]	4531 (3.0)	144 915 (97.0)	Ref
2–4	440 (1.3)	33 207 (98.7)	Ref	690 (3.7)	18 008 (96.3)	<.001
5–11	733 (1.9)	38 761 (98.1)	<.001	1318 (4.9)	25 619 (95.1)	<.001
12–17	420 (3.4)	11 758 (96.6)	<.001	787 (8.0)	9080 (92.0)	<.001
Gender						
Girls	660 (2.0)	31 901 (98.0)	Ref	4027 (3.5)	110 221 (96.5)	Ref
Boys	935 (1.8)	51 824 (98.2)	.019	3300 (3.6)	87 395 (96.4)	.23
Race						
White	321 (1.3)	24 112 (98.7)	Ref	2885 (3.3)	84 798 (96.7)	Ref
Black	650 (2.1)	29 681 (97.9)	<.001	1095 (3.2)	33 186 (96.8)	.40
Hispanic	336 (1.8)	18 092 (98.2)	<.001	1870 (3.7)	48 306 (96.3)	<.001
Asian or Pacific Islander	60 (2.7)	2192 (97.3)	<.001	263 (4.7)	5305 (95.3)	<.001
Native American	<10 (0.0)	639 (100.0)	.29	40 (1.6)	2453 (98.4)	<.001
Unknown[d]	222 (2.4)	9009 (97.6)	<.001	1174 (4.7)	23 575 (95.3)	<.001
Patient's residence[e]						
Urban	1446 (2.0)	69 398 (98.0)	Ref	6212 (4.2)	143 376 (95.8)	Ref
Rural	146 (1.0)	14 235 (99.0)	<.001	1100 (2.0)	53 972 (98.0)	<.001
Payment source						
Public insurance	1069 (2.1)	50 202 (97.9)	Ref	4538 (3.7)	119 596 (96.3)	Ref
Private insurance	421 (1.5)	27 924 (98.5)	<.001	2364 (3.5)	65 979 (96.5)	.026
Self-pay/no charge/other[f]	103 (1.9)	5428 (98.1)	.27	420 (3.5)	11 459 (96.5)	.50
Median household income quartile						
Quartile 1	627 (1.9)	32 465 (98.1)	Ref	2295 (3.1)	72 011 (96.9)	Ref
Quartile 2	362 (1.9)	18 710 (98.1)	.98	1728 (3.5)	47 729 (96.5)	<.001
Quartile 3	289 (1.7)	16 400 (98.3)	.20	1732 (4.0)	41 638 (96.0)	<.001
Quartile 4	243 (1.7)	13 691 (98.3)	.27	1434 (4.3)	31 805 (95.7)	<.001
No. of chronic conditions						
0	N/A[c]	N/A[c]	N/A[c]	1441 (1.2)	118 053 (98.8)	Ref
1	730 (1.1)	65 932 (98.9)	Ref	1138 (2.0)	54 741 (98.0)	<.001
2–4	618 (3.5)	16 911 (96.5)	<.001	2126 (9.2)	20 968 (90.8)	<.001
>4	247 (21.9)	882 (78.1)	<.001	2622 (40.4)	3862 (59.6)	<.001
Discharge quarter						
Jan–Mar	402 (2.0)	19 872 (98.0)	Ref	2936 (3.2)	88 525 (96.8)	Ref
Apr–Jun	353 (1.9)	17 963 (98.1)	.69	1511 (4.5)	31 913 (95.5)	<.001
Jul–Sept	354 (1.8)	19 627 (98.2)	.12	879 (4.1)	20 713 (95.9)	<.001
Oct–Dec	484 (1.8)	26 250 (98.2)	.17	1998 (3.4)	56 442 (96.6)	.027
Hospital bed size						
Small	126 (1.2)	10 596 (98.8)	Ref	526 (2.1)	24 134 (97.9)	Ref
Medium	357 (1.7)	20 395 (98.3)	<.001	1570 (3.2)	47 769 (96.8)	<.001
Large	1112 (2.1)	52 734 (97.9)	<.001	5231 (4.0)	125 719 (96.0)	<.001
Hospital location/teaching status						
Rural	27 (0.0)	6372 (100.0)	Ref	129 (0.0)	26 934 (100.0)	Ref
Urban nonteaching	113 (0.1)	17 058 (99.9)	.035	615 (1.2)	51 757 (98.8)	<.001
Urban teaching	1454 (2.4)	60 296 (97.6)	<.001	6583 (5.2)	118 931 (94.8)	<.001

TABLE 3 Continued

Characteristic	Asthma			LRI		
	Complication, *n* (%), Weighted, *n* = 1595	No Complication, *n* (%), Weighted, *n* = 83 725	*P*[a]	Complication, *n* (%), Weighted, *n* = 7327	No Complication, *n* (%), Weighted, *n* = 197 623	*P*[a]
Geographic region						
Northeast	472 (2.2)	20 764 (97.8)	Ref	1515 (4.1)	35 036 (95.9)	Ref
Midwest	259 (1.6)	16 125 (98.4)	<.001	1594 (3.7)	41 115 (96.3)	.003
South	629 (2.0)	30 423 (98.0)	.12	2506 (3.1)	79 362 (96.9)	<.001
West	235 (1.4)	16 414 (98.6)	<.001	1712 (3.9)	42 109 (96.1)	.09
Control/ownership of hospital						
Government nonfederal	190 (1.7)	11 139 (98.3)	Ref	670 (2.6)	24 884 (97.4)	Ref
Private nonprofit	1281 (2.0)	61 678 (98.0)	.012	6155 (4.1)	144 086 (95.9)	<.001
Private investor-owned	124 (1.1)	10 909 (98.9)	<.001	502 (1.7)	28 653 (98.3)	<.001

[a] Univariate comparisons done by using χ^2 tests.
[b] Age was divided into categories for the purposes of univariate comparisons. The categories chosen are based on the National Heart, Lung, and Blood Institute Asthma Guidelines.
[c] No hospitalizations in this category.
[d] Due to a large number of missing values (>8%), the category "Other" and missing values were combined to create the "Unknown" category.
[e] Urban defined as counties with populations >250 000 residents.
[f] Due to small cell sizes, these categories were grouped.

1.08, 95% CI 1.02–1.15), Asian children compared with white children (AOR 1.28, 95% CI 1.03–1.59), and in children with chronic medical conditions (AOR 56.22, 95% CI 46.60–68.82 for >4 conditions compared with no conditions). Odds of complications were higher in hospitalizations to large hospitals (AOR 1.42, 95% CI 1.11–1.83) and urban-teaching hospitals compared with rural hospitals (AOR 5.43, 95% CI 4.17–7.08).

DISCUSSION

Asthma and LRI represent the most significant burdens on child health in the inpatient setting.[1] Our study sought to identify patient- and hospital-level factors associated with prolonged LOS and complications during these hospitalizations by using a nationally representative sample. During pediatric hospitalizations for asthma, we found risks were increased for older children and those with chronic conditions. During pediatric hospitalizations for LRI, we found risks were increased for younger children and those with chronic conditions. For both asthma and LRI, risks were higher in large, urban-teaching hospitals.

We found the risks of both prolonged LOS and complications were increased during asthma hospitalizations of older children. Odds of prolonged LOS increased 5% and complications increased 6% for every year of age, making the odds of these events up to 78% higher in adolescents. Previous studies examining risk factors for longer LOS[11] and complications[12] during pediatric asthma hospitalizations have not found older age to increase risks of these outcomes; however, these were small, single-center studies.

Adolescents with asthma are a vulnerable group at significant risk of experiencing complications because of underrecognition and denial of disease severity, poor medication adherence, and other risk-taking behaviors.[25] These factors may lead to later, more severe presentations and consequent longer stays with higher risks of complications. During hospitalizations, providing quality disease management education may play a crucial role in improving disease control, thereby reducing risk of subsequent severe asthma exacerbations and complications.[26] Efforts to improve outpatient medication adherence[24] and transition to adult care providers[27,28] are also important for improving outcomes in this challenging age group. The US Maternal and Child Health Bureau formed the Center for Health Care Transition to support research and policy efforts to improve transitions from pediatric to adult health care. Continued support of such efforts to improve transitions is crucial to improving health outcomes for adolescents with asthma.

We found the risks of both prolonged LOS and complications during LRI hospitalizations were increased in younger children. Odds of prolonged LOS decreased 2% and complications decreased 5% for every year of age, making the odds of these events up to 85% higher in infants. Pati et al[18] also found risks of prolonged LOS were highest in the youngest children admitted for pneumonia. Possible reasons include more severe disease courses in younger children or greater variation in care of young children, such as in the use of pulse oximetry. Oxygen saturation has been implicated as the primary determinant of LOS during hospitalizations for bronchiolitis,[29,30] and a study by Schroeder et al[29] found that 1 in 4 patients incur unnecessarily prolonged hospitalization as a result of a perceived need for oxygen outside of other symptoms. Current guidelines on the management of bronchiolitis from the American Academy of Pediatrics suggest clinicians decrease utilization of continuous pulse oximetry as a means of decreasing unnecessarily prolonged hospitalization.[31]

We found a strong relationship between the presence of chronic medical conditions and increased risks of prolonged LOS or

TABLE 4 Patient- and Hospital-Level Factors Associated with Prolonged LOS or Complications

Characteristic	Asthma, Weighted, $n = 85\,320$		LRI, Weighted, $n = 204\,950$	
	Prolonged LOS,[a] AOR[b] (95% CI)	Complications, AOR[b] (95% CI)	Prolonged LOS,[a] AOR[b] (95% CI)	Complications, AOR[b] (95% CI)
Age	1.06 (1.05–1.07)	1.05 (1.03–1.07)	0.98 (0.97–0.98)	0.95 (0.94–0.96)
Gender				
Girls	1.17 (1.10–1.23)	1.06 (0.93–1.20)	1.13 (1.10–1.17)	1.08 (1.02–1.15)
Race				
White	Ref	Ref	Ref	Ref
Black	1.01 (0.91–1.11)	1.35 (1.10–1.66)	0.82 (0.76–0.88)	0.86 (0.76–0.97)
Hispanic	1.10 (0.97–1.24)	1.21 (0.93–1.57)	1.06 (0.98–1.15)	1.01 (0.87–1.18)
Asian or Pacific Islander	1.02 (0.85–1.24)	2.29 (1.38–3.79)	1.09 (0.99–1.22)	1.28 (1.03–1.59)
Native American	1.03 (0.69–1.53)	0.73 (0.24–2.23)	1.16 (0.96–1.40)	0.66 (0.41–1.05)
Unknown[c]	1.00 (0.89–1.13)	1.73 (1.00–3.00)	1.07 (0.96–1.17)	1.38 (1.07–1.77)
Patient's residence[d]				
Urban	0.96 (0.84–1.11)	1.13 (0.84–1.52)	1.05 (0.97–1.15)	1.08 (0.95–1.22)
Payment source				
Private insurance	Ref	Ref	Ref	Ref
Public insurance	1.13 (1.06–1.21)	1.24 (1.05–1.46)	1.14 (1.09–1.19)	1.05 (0.95–1.15)
Self-pay/no charge/other[e]	1.00 (0.88–1.14)	1.33 (0.94–1.87)	1.10 (0.98–1.24)	1.01 (0.83–1.23)
Median household income quartile				
Quartile 1	Ref	Ref	Ref	Ref
Quartile 2	1.03 (0.95–1.11)	1.10 (0.89–1.35)	0.97 (0.92–1.02)	0.98 (0.88–1.09)
Quartile 3	1.02 (0.92–1.13)	0.94 (0.78–1.12)	0.94 (0.88–1.00)	0.95 (0.84–1.08)
Quartile 4	0.98 (0.86–1.12)	1.05 (0.81–1.37)	0.93 (0.85–1.01)	1.03 (0.89–1.20)
No. of chronic conditions				
0	N/A[f]	N/A[f]	Ref	Ref
1	Ref	Ref	1.45 (1.38–1.51)	1.78 (1.57–2.01)
2–4	1.72 (1.60–1.85)	2.95 (2.36–3.68)	3.86 (3.66–4.07)	8.17 (6.91–9.66)
>4	4.87 (4.15–5.70)	21.20 (15.20–29.57)	9.86 (9.03–10.76)	56.22 (46.60–67.82)
Discharge quarter				
Jan–Mar	Ref	Ref	Ref	Ref
Apr–Jun	0.76 (0.70–0.82)	0.92 (0.76–1.11)	0.90 (0.85–0.94)	1.09 (0.97–1.21)
Jul–Sept	0.72 (0.67–0.78)	0.92 (0.75–1.13)	0.73 (0.69–0.78)	0.94 (0.83–1.06)
Oct–Dec	0.84 (0.78–0.90)	0.90 (0.74–1.10)	0.82 (0.78–0.86)	0.95 (0.86–1.04)
Hospital bed size				
Small	Ref	Ref	Ref	Ref
Medium	1.61 (1.24–2.09)	1.25 (0.74–2.12)	1.09 (0.95–1.25)	1.23 (0.92–1.63)
Large	1.67 (1.32–2.11)	1.67 (1.03–2.73)	1.30 (1.16–1.46)	1.43 (1.11–1.83)
Hospital location and teaching status				
Rural	Ref	Ref	Ref	Ref
Urban nonteaching	1.55 (1.27–1.90)	1.48 (0.79–2.77)	1.64 (1.43–1.87)	2.02 (1.48–2.75)
Urban teaching	1.62 (1.33–1.97)	4.07 (2.25–7.36)	2.41 (2.12–2.74)	5.43 (4.17–7.09)
Geographic region				
Midwest	Ref	Ref	Ref	Ref
Northeast	1.16 (0.91–1.47)	1.47 (1.02–2.12)	0.86 (0.76–0.96)	1.23 (0.95–1.58)
South	1.15 (0.94–1.41)	1.66 (0.98–2.82)	1.04 (0.93–1.17)	1.05 (0.84–1.31)
West	1.16 (0.93–1.45)	1.12 (0.69–1.83)	1.10 (0.97–1.25)	1.10 (0.87–1.40)

TABLE 4 Continued

Characteristic	Asthma, Weighted, $n = 85\,320$		LRI, Weighted, $n = 204\,950$	
	Prolonged LOS,[a] AOR[b] (95% CI)	Complications, AOR[b] (95% CI)	Prolonged LOS,[a] AOR[b] (95% CI)	Complications, AOR[b] (95% CI)
Control/ownership of hospital				
Private nonprofit	Ref	Ref	Ref	Ref
Private Investor-owned	1.13 (0.90–1.47)	0.68 (0.40–1.13)	0.90 (0.81–1.00)	0.84 (0.65–1.10)
Government nonfederal	1.22 (1.01–1.47)	0.72 (0.44–1.17)	1.01 (0.88–1.16)	0.84 (0.63–1.11)

[a] Prolonged length of stay was defined as the 90th percentile of the LOS distribution for each condition (asthma 3.3 days, LRI 5 days).
[b] AOR, calculated using a multivariable regression model including patient factors age, gender, race, place of residence, payment source, income quartile, and number of chronic conditions, and the hospital factors bed size, location and teaching status, geographic region, and ownership.
[c] Due to a large number of missing values (>8%), the category "Other" and missing values were combined to create the "Unknown" category.
[d] Urban defined as counties with populations >250 000 residents.
[e] Due to small cell sizes, these categories were grouped.
[f] No hospitalizations in this category.

complications for both asthma and LRI hospitalizations. During asthma hospitalizations, children with >4 chronic conditions had nearly fivefold increased odds of prolonged LOS and >20-fold odds of complications. During LRI hospitalizations, children with >4 chronic conditions had nearly 10-fold increased odds of prolonged LOS and >50-fold odds of complications. Our findings support those of Simon et al,[19] who found, from 1997 to 2006, children with complex chronic conditions were using an increasing proportion of inpatient care (26% of inpatient days in 2006) and had intensive inpatient resource use, with median LOS >3 times longer and risk of mortality 15 times higher than those with no chronic conditions. The Institute of Medicine has prioritized medical homes for improving health care for this vulnerable population.[32] Better coordination of inpatient and outpatient care also has shown potential for improving outcomes in children with chronic conditions,[32,33] and the Affordable Care Act's support of developing Accountable Care Organizations may provide opportunities for better integration of inpatient and outpatient care. In the inpatient setting, hospital-based care coordination has been shown to decrease inpatient days and hospital costs.[34] Given the rising proportion of children with chronic conditions cared for in hospital and these children's substantially increased risk of poor outcomes, it is imperative that we better determine the effectiveness of interventions such as hospital-based care coordination and consider developing policies that incentivize hospitals to implement such programs.

We also found hospitalizations of children with public insurance had higher risks of prolonged LOS in both asthma and LRI and higher risks of complications in asthma. These findings are in line with several previous studies,[12,18,35,36] and are likely due to multiple factors that may include worse disease severity on presentation.[37] Additional research is necessary to understand whether there are differences in processes of care, quality of care, or other outcomes related to inpatient management for children with different insurance coverage.[18]

For both asthma and LRI, we found hospitalizations to large, urban-teaching hospitals had higher risk of prolonged LOS and complications. Similar associations have been found in analyses of children admitted for pneumonia,[18] common pediatric conditions,[21] and all-cause pediatric hospitalizations.[36] Teaching hospitals have been shown to have longer LOS and higher costs even after adjustment for case severity and socioeconomic status (SES),[21] as we have done in our analysis. One potential reason for this finding may be decreases in efficiency in teaching hospitals as a result of trainee supervision.[18] Another reason may be limits in our ability to completely control for the higher proportion of children with complex conditions and low-SES in teaching hospitals.[21] However, given that these types of hospitals are serving a disproportionately large share of medically complex and low-SES children, these hospitals should prioritize implementation of interventions shown to improve quality of care for children admitted with respiratory illness. Single-center studies have shown clinical pathways improve antimicrobial use[38] and reduce radiation exposure, video-assisted thoracoscopic surgery procedures, and readmission rates in children admitted for pneumonia[9]; reduce resource utilization,[39–41] LOS,[41] and readmissions[8] in children admitted for bronchiolitis; and increase home asthma management teaching[7] and decrease in LOS[5,42] in children admitted for asthma. Larger, multicenter studies are needed to determine if clinical pathways are an effective means of improving quality of care for respiratory illnesses, and if pathways are found to be effective, policies should incentivize large, urban-teaching hospitals to implement pathways.

There are several limitations to our analysis. First, KID contains discharge-level records rather than patient-level records, so a single child may be represented multiple times if readmitted to hospital over the study interval. Second, KID does not include detailed clinical variables, such as each child's level of asthma severity and control; so, as with any observational study, our findings may be confounded by these factors. We adjusted for severity of case-mix by using number of chronic conditions, as specified in the National Quality Forum metric,[4] but there may be residual confounding that effects our analysis of hospital-level risk factors for prolonged LOS and complications. In

addition, LOS data do not account for time spent in the emergency department, so systematic variations in emergency department management that affect hospital LOS could bias our results; however, we do not suspect such systematic differences in emergency department care.

By using this nationally representative sample, we found older children with asthma, younger children with LRI, children with chronic medical conditions, and those admitted to large urban-teaching hospitals are more vulnerable to prolonged LOS and complications during hospitalizations. Further research efforts are needed to determine effective interventions to improve care for these high-risk groups and policy efforts are needed to help support implementation of effective interventions.

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APPENDIX Codes Used to Identify Children with LRI

ICD-9-CM Diagnosis Code	ICD-9-CM Diagnosis Code Description
4660	ACUTE BRONCHIOLITIS
46611	ACUTE BRONCHIOLITIS DUE TO RESPIRATORY SYNCYTIAL VIRUS (RSV)
46619	ACUTE BRONCIOLITIS DUE TO OTHER INFECTIOUS ORGANISMS
4801	VIRAL PNEUMONIA DUE TO RESPIRATORY SYNCYTIAL VIRUS
4870	INFLUENZA WITH PNEUMONIA
4871	INFLUENZA WITH OTHER RESPIRATORY MANIFESTATIONS
4878	INFLUENZA WITH OTHER MANIFESTATIONS
4881	INFLUENZA DUE TO IDENTIFIED NOVEL H1N1 INFLUENZA VIRUS
00322	*SALMONELLA* PNEUMONIA
0116	TUBERCULOUS PNEUMONIA
0212	PULMONARY TULAREMIA
0221	PULMONARY ANTHRAX
0310	PULMONARY INFECTION BY *MYCOBACTERIUM AVIUM*, INTRACELLULARE, KANSASII
0330	BORDETELLA PERTUSSIS [B. PERTUSSIS]
0331	BORDETELLA PARAPERTUSSIS [B. PARAPERTUSSIS]
0338	WHOOPING COUGH DUE TO OTHER SPECIFIED ORGANISM
0339	WHOOPING COUGH, UNSPECIFIED ORGANISM
0391	PULMONARY ACTINOMYCOSIS
0521	VARICELLA (HEMORRHAGIC) PNEUMONIA
0551	POST-MEASLES PNEUMONIA
0730	ORNITHOSIS WITH PNEUMONIA
0796	RSV, OTHER
0951	SYPHILIS OF LUNG
1124	CANDIDAL PNEUMONIA
1140	PRIMARY COCCIDIOMYCOSIS (PULMONARY)
11505	HISTOPLASM CAPS PNEUMON (INFECTION BY HISTOPLASM CAPSULATUM, PNEUMONIA)
11515	HISTOPLASM DUB PNEUMONIA (INFECTION BY HISTOPLASM DUBOISII, PNEUMONIA)
11595	HISTOPLASMOSIS WITH PNEUMONIA
1304	PNEUMONITIS DUE TO TOXOPLASMOSIS
1363	PNEUMOCYSTOSIS
4800	VIRAL PNEUMONIA DUE TO ADENOVIRUS
4802	VIRAL PNEUMONIA DUE TO PARAINFLUENZA VIRUS
4803	VIRAL PNEUMONIA DUE TO SARS-ASSOCIATED CORONAVIRUS
4808	VIRAL PNEUMONIA DUE TO OTHER VIRUS NOT ELSEWHERE CLASSIFIED
4809	VIRAL PNEUMONIA, UNSPECIFIED
481	PNEUMOCOCCAL PNEUMONIA [NO 4TH OR 5TH DIGIT EXISTS IN THE ICD-9 SYSTEM FOR THIS CODE]
4820	PNEUMONIA DUE TO *KLEBSIELLA PNEUMONIAE*
4821	PNEUMONIA DUE TO *PSEUDOMONAS*
4822	PNEUMONIA DUE TO *HAEMOPHILUS INFLUENZAE*
4823×	PNEUMONIA DUE TO *STREPTOCOCCUS*
4824×	PNEUMONIA DUE TO *STAPHYLOCOCCUS*
4828×	PNEUMONIA DUE TO OTHER SPECIFIED BACTERIA
4829	BACTERIAL PNEUMONIA UNSPECIFIED
483×	PNEUMONIA DUE TO OTHER SPECIFIED ORGANISM

APPENDIX Continued

ICD-9-CM Diagnosis Code	ICD-9-CM Diagnosis Code Description
484×	PNEUMONIA IN INFECTIOUS DISEASES CLASSIFIED ELSEWHERE
485	BRONCHOPNEUMONIA [NO 4TH OR 5TH DIGIT EXISTS IN THE ICD-9 SYSTEM FOR THIS CODE]
486	PNEUMONIA, ORGANISM UNSPECIFIED [NO 4TH OR 5TH DIGIT EXISTS IN THE ICD-9 SYSTEM FOR THIS CODE]