Rehospitalization for Childhood Asthma: Timing, Variation, and Opportunities for Intervention

Chén C. Kenyon, MD[1,2], Patrice R. Melvin, MPH[3], Vincent W. Chiang, MD[2,4], Marc N. Elliott, PhD[5], Mark A. Schuster, MD, PhD[2,4], and Jay G. Berry, MD, MPH[2,4]

Objective To assess the timing of pediatric asthma rehospitalization, variation in rate of rehospitalization across hospitals, and factors associated with rehospitalization at different intervals.

Study design Retrospective cohort analysis of 44 204 hospitalizations for children with asthma within 42 children's hospitals between July 2008 and June 2011. The main outcome measures were rehospitalization for asthma within 7, 15, 30, 60, 180, and 365 days of an index asthma admission.

Results The rate of asthma rehospitalization ranged from 0.5% (n = 208) at 7 days to 17.2% (n = 7603) at 365 days. Black patients and patients with public insurance had higher odds of rehospitalization at 60 days and beyond ($P \leq .01$ for both). Adolescents (12- to 18-year-old), patients with a diagnosis of a complex chronic condition, and patients with a prior year asthma admission had higher odds of rehospitalization at every time interval ($P \leq .001$ for all). Significant hospital variation in case-mix adjusted rates of rehospitalization existed at each time interval ($P \leq .01$ for all). Rates at 365 days were $\leq 10.9\%$ for the top 10% of hospitals; if all hospitals achieved this rate, 36.6% of rehospitalizations might have been avoided.

Conclusions Significant variation in asthma rehospitalization rates exists across children's hospitals from 7 to 365 days after an index admission. Racial/ethnic and economic disparities emerge at 60 days. By 1 year, rehospitalizations account for 1 in 6 hospitalizations. Assessing asthma rehospitalizations at longer intervals may augment our current understanding of and approach to post-hospitalization care improvement. (*J Pediatr 2014;164:300-5*).

Although only a small percentage of the nearly 7 million US children with asthma are admitted to the hospital in a given year, hospitalization accounts for nearly one-third of national pediatric asthma costs.[1,2] Prior studies demonstrate that upwards of 40% of pediatric asthma hospitalizations are repeat hospitalizations (ie, the child has been hospitalized for asthma previously),[3-5] suggesting that reduction of repeat hospitalization may be an important priority area for care improvement. Furthermore, some repeat hospitalizations are avoidable; a number of hospital-centered interventions have reduced repeat hospitalization well beyond the month after discharge.[6-9]

However, in clinical practice, it is difficult to determine which hospitalized children with asthma are at risk for experiencing a subsequent asthma rehospitalization. Delineating risk factors for short- and long-term asthma rehospitalization may help to target discharge transition and chronic care improvement efforts to high-risk populations. Therefore, we performed a retrospective cohort analysis of asthma hospitalizations at 42 US children's hospitals to describe the prevalence and timing of repeat hospitalization for pediatric asthma and the factors associated with rehospitalization at different time intervals. We also assessed variation in asthma rehospitalization rates across hospitals and local areas to describe what rates might be achievable with high quality of care.

Methods

This is a longitudinal, retrospective cohort study of the Pediatric Health Information System (PHIS), an administrative database with inpatient data from 42 free-standing children's hospitals affiliated with the Children's Hospital Association. Included hospitals are distributed throughout the 4 US census regions (Northeast [16.7%], South [33.3%], Midwest [26.2%], and West [23.8%]). All are located in urban metropolitan statistical areas. The median bed-size of the hospitals was 290 (IQR 247, 343). All but one was categorized as a teaching hospital. PHIS has a unique identifier for each patient that permits longi-

APR-DRG	All-Patient Refined Diagnosis-Related Group
CCC	Complex chronic condition
ICU	Intensive care unit
PHIS	Pediatric Health Information System

tudinal tracking of individual patients rehospitalized to the same PHIS hospital. The Boston Children's Hospital Institutional Review Board approved the study.

We analyzed hospital discharges of patients ≥2-years-old admitted for asthma (All-Patient Refined Diagnosis-Related Group [APR-DRG] of asthma [v20 141]) from 7/1/08-6/30/10, following each child for 365 days from the date of discharge within this interval. Children <2-years-old were excluded because other wheezing disorders (eg, bronchiolitis) often confound the diagnosis of asthma. We excluded index hospitalizations during which patients died.

Outcome measures were repeat admission to the same hospital for asthma (APR-DRG v20 141) within 7, 15, 30, 60, 180, and 365 days of an index admission for asthma. If a patient was hospitalized again following a rehospitalization within 365 days of the index admission, the initial rehospitalization was counted as an index admission for the second rehospitalization, and so forth.

Demographic characteristics included age at index admission (using National Heart, Lung, and Blood Institute age ranges of 2-4, 5-11, 12-18, and >18 years), race/ethnicity (non-Hispanic Black, non-Hispanic White, Hispanic, Other), sex, and primary insurance at index admission (public, private, self-pay/no-charge, other type of insurance).

We used an existing grouping of pediatric complex chronic conditions (CCC) to assess whether comorbid conditions influence the risk of asthma rehospitalization. CCC indicate the presence of a chronic illness that is expected to last ≥12 months and involve multiple organ systems or involve 1 organ system but require specialty pediatric care and hospitalization. CCC include pediatric cardiovascular, congenital/genetic defect, gastrointestinal, hematologic, malignancy, metabolic, neuromuscular, renal, and respiratory diagnoses[10]; these diagnoses are associated with higher risk of repeat admission.[11] Presence of a CCC was identified with *International Classification of Diseases-9-Clinical Modification* codes. Up to 21 diagnosis codes are provided per hospitalization.

Index hospitalization characteristics included use of magnesium for enhanced bronchodilation, APR-DRG severity of illness (mild [1]; moderate [2]; severe [3]; and extremely severe [4]), use of intensive care unit (ICU) services during the admission, length of hospital stay, and discharge disposition (to home with or without nursing, or post-discharge care facility). We also included asthma admission in the year prior to the index admission, which has been strongly associated with asthma rehospitalization in prior studies.[4,12]

Statistical Analyses

Demographic, clinical, and hospitalization characteristics were compared for index hospitalizations where another hospitalization did and did not occur within 365 days using χ^2 tests. Covariates with a *P* value <.20 in bivariate analysis were retained in a multivariate logistic regression model with generalized linear mixed effects using the hospital variable as a random effect at each readmission time interval. Although we labeled this random effect "hospital," we acknowledge

that it likely includes effects that may be attributable to outpatient and community-level factors that influence rehospitalization rates. In multivariate analysis, variables retained in the final model were included at each time interval to allow comparison of the models across time intervals. *P* values <.05 were considered statistically significant.

To estimate potentially avoidable rehospitalizations at each interval, we rank-ordered each hospital by its rehospitalization rate, adjusted for age and CCC, and determined the rate corresponding with the top decile of hospitals (the 10% with the lowest rates). Performance at the 10th percentile has been used to establish performance benchmarks.[13] We determined the number of rehospitalizations that would be avoided if each hospital's adjusted rate was equivalent to the 10th performance percentile. We then calculated a potential inpatient cost savings estimate for these 42 hospitals by multiplying this estimated proportion of avoidable rehospitalizations by the overall cost of rehospitalization for all hospitals in that interval. To assess the stability of observed hospital rehospitalization rankings, we performed a Spearman correlation of hospital rankings in the first year (2009) to the second year (2010) for 2 rehospitalization intervals (30 and 365 days).

Costs were estimated using the adjusted total ratio of costs to charges variable reported in PHIS, which reflects the total charges reported by the hospital adjusted by the Centers for Medicare and Medicaid Services wage/price index for the hospital's location. Data were analyzed using SAS software, v. 9.2 (SAS Institute, Cary, North Carolina).

Results

From July 1, 2008-June 30, 2010, 36 601 patients had 44 204 hospitalizations in 42 children's hospitals. Characteristics of the cohort appear in **Table I**. Asthma rehospitalization rates ranged from 0.5% (n = 208) at 7 days to 17.2% (n = 7603) at 365 days (**Figure**), and aggregate costs of asthma rehospitalizations ranged from $3.3 million at 7 days to $30.8 million at 365 days. Of patients rehospitalized within 365 days, 75.0% had 1 repeat admission, 15.9% had 2, 5.0% had 3, and 4.1% had ≥4.

Bivariate Analysis

At 365 days, rehospitalization varied significantly by race/ethnicity (*P* ≤ .001), with lower rates for Whites (11.9%) than for Blacks (22.2%) or Hispanics (14.5%). Rehospitalization rates also varied by age (*P* ≤ .001), with higher rates observed in 12- to 18-year-olds (22.8%) than 5- to 11-year-olds (16.5%) and 2- to 4-year-olds (15.9%). There was also significant variation in repeat hospitalization by insurance status (*P* ≤ .001), with higher rates, for example, for children with public insurance (19.6%) vs private insurance (13.4%). Patients with a CCC had higher rehospitalization rates than patients without a CCC (25.7% vs 16.5%, *P* ≤ .001).

Rates also varied by length of stay (*P* ≤ .001), ranging from 13.8% for those admitted for 1 day to 23.3% for those admitted for ≥5 days. Rehospitalization rates were higher in patients who experienced a prior asthma admission during