IMPACT OF INITIAL LENGTH OF STAY (ILOS) ON 30-DAY READMISSION RISK IN PEDIATRIC ASTHMA PATIENTS: IMPLICATIONS FOR ACCOUNTABLE CARE

A Thesis

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To my father, Dr. M. Dean Knighton, for his commitment to education and to the belief that the pursuit of knowledge can improve lives.

ABSTRACT

Objectives. The trend towards more accountable care puts pressure on hospitals to manage care episodes, including the risk of readmission. The emphasis on reducing readmissions implies that an association exists between the utilization of hospital resources and readmission risk. This study was designed to explore this association in a cohort of pediatric asthma patients.

Materials/Methods. The sample cohort (n=4965) included all asthma discharges from January 2008 through August 2012 discharged from Children's Hospitals and Clinics of Minnesota (CHC MN). Asthma discharges included cases with a principal diagnosis of asthma or certain respiratory cases with asthma listed as a secondary diagnosis. Multiple logistic regression was used to test associations, adjusting for covariates.

Results. Adjusting for covariates, we found no significant association between initial length of stay (ILOS) and readmission (OR:1.04[95%CI:0.98-1.10]). Analyzing ILOS categorically by day, one-day stays did not have a significantly higher readmission risk (OR:1.27[95% CI: 0.87-1.85]) than two-day stays, which had the lowest observed readmission risk. Risk increased as ILOS exceeded 2 days but was not significantly different by day. We found no association when comparing the difference in actual vs expected ILOS and readmission risk (shorter than expected OR:1.13[95%CI:0.74-1.71]; longer than expected OR:0.97[95%CI:0.69-1.38]).

Conclusions. Altering ILOS is not likely to reduce readmissions in pediatric asthma patients. For example, increasing one-day visits to two-day visits would increase hospital patient days 38% (1870 days) in this cohort while decreasing total readmissions by 3.8%[95%CI:3.6-4.0%]. Attempts to prolong ILOS would dramatically increase costs with little reduction in readmissions.

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BACKGROUND AND SIGNIFICANCE

Preventable readmissions have been identified as a potential indicator of quality of care and patient health and well being, though disagreement remains (Ashton, 1996; Benbassat, 2000; Goldfield, 2008; Berenson, 2010). Some researchers remain skeptical regarding the level of readmissions that are truly preventable (VanWalRaven, 2011) as well as the association between hospital care and readmission risk (Kossovsky, 2000; Joynt, 2010). Despite this, payers (including Medicaid and commercial plans) are incorporating financial incentives into hospital contracts that are designed to reduce readmissions. Such incentives include "bundled payments" and accountable care models that move away from traditional fee for service payment towards paying providers for successful treatment of an episode of care (Berkowitz, 2011; Cutler 2012).

While CMS has utilized an Inpatient Prospective Payment System (IPPS) historically to cap payments for treatment of conditions based upon condition severity, payers in general have not penalized hospitals for potentially preventable readmissions. In 2007 (responding to the 2005 Deficit Reduction Act), Medicare developed Hospital Acquired Conditions/Present on Admission (HAC/POA) rules that prevent the assignment of higher reimbursements for treatment of hospital-acquired conditions. Some state Medicare programs as well as private payers followed suit (Keefe, 2008). Under the Patient Protection and Affordable Care Act (2010), Medicaid regulations prohibit Federal payments to states for amounts expended for treating Health-Care Acquired Conditions (HCAC). The final rule issued June 30, 2011, requires states to implement non-payment policies for provider-preventable conditions (PPCs) including HCACs (CMS, 2011). Recently, Medicare penalized 2,211 hospitals for excess readmission rates applied through global reimbursement reductions (Rau, 2012).

While meaningful research on the impact of readmissions on quality of care and cost has been conducted among the general adult inpatient population, more research is

needed to understand the nature and impact of readmissions on pediatric patients and hospitals (Gay 2011). The nature, treatment and ongoing care for childhood disease can differ substantially from the care and treatment of adults suggesting the need for further study (Vest, 2012). Recent research in this area further confirms that the volume of readmission is significantly lower than for the adult population and that only a small sub-population (~20%) of pediatric readmissions may actually be preventable (Hain, 2013).

The Ohio Children's Hospitals Solutions for Patient Safety (OCHSPS) is a national collaborative of children's hospitals that have organized to improve patient safety. The mission of this federally-funded hospital engagement network (HEN) is to "work together to accelerate cultural and process improvements to eliminate serious harm across all children's hospitals in the United States." Under an agreement with CMS, efforts are focused on reducing the level of hospital-acquired conditions in 11 specific areas, including preventable readmissions (Lyren, 2012).

Children's Hospitals and Clinics of Minnesota (CHC MN), along with the Primary Children's Medical Center in Utah, were selected to lead the effort to reduce preventable readmissions on behalf of the collaborative. CHC MN is a large, independent children's hospital system located in Minneapolis. CHC MN is a safety net hospital, serving the urban needs of poorer, more diverse, multi-racial and multilingual residents in the Twin Cities and the upper Midwest. Services include general inpatient, emergency and home health care, as well as specialty care, including ICU, NICU and Cardiac ICU. CHC MN inpatient services treat about 13,000 patients annually along with 200,000 ER visits and outpatient visits (CHC MN, 2012).

This study was conducted as part of the broader effort being made by OCHSPS and CHC MN to understand the impact of readmissions on the pediatric population. IRB approval was obtained through CHC MN (IRB# 1207-067) and the University of Minnesota (IRB# 1209E20042).

UNDERSTANDING READMISSIONS

A readmission is generally defined as a rehospitalization within a given established time frame (3, 7, 15, 30, 45-days+). This study focuses on the measurement of a 30-day readmission standard given its use by CMS in measurement of chronic treatment in adults (CMS, 2011). Previous research into the primary causes of readmissions in the adult population point to a number of risk factors grouped into patient demographics, disease characteristics and care received. Patient demographics identified as risk factors in previous studies include age, race, socio-economic status and hospital proximity. Disease characteristics include type and severity of disease, presence of mental health, substance abuse or other co-morbidities. Factors related to care include length of time between initial admit and readmission, prior use of hospital resources, patient self-management, hospital admission rates, hospital capacity and the presence of a transition care plan (Jencks, 2009).

Among studies focused specifically on readmission risk on children, primary risk factors for readmission include the presence of complex comorbid conditions, race and use of medicaid (Feudtner, 2009; Mackie, 2008; Czaja, 2009). These risk factors are consistent with studies of pediatric asthma patients (Reznick, 2006; Marcos, 2006; Carroll, 2010; Liu, 2009). Despite this research, estimating readmission risk remains a "complex endeavor" that is still "poorly understood" (Kansagara, 2011).

UNDERSTANDING PEDIATRIC ASTHMA

Asthma remains the most common chronic condition for children and a significant driver of hospitalizations. Over 10 million U.S. children aged 17 and under (14% of the population) have been diagnosed with asthma at one point in their lives; 7 million children still have asthma (10%). Boys are more likely than girls (16% vs 12%) to have

ever been diagnosed and the disease weighs disproportionately on non-Hispanic Black/African-American children (Bloom, 2011). Despite the high prevelance of asthma in children, diagnosis and treatment of asthma remains a challenge.

Natural History. An international consensus report on childhood asthma defines asthma as "repeated attacks of airway obstruction and intermittent symptoms of increased airway responsiveness to triggering factors, such as exercise, allergen exposure and viral infections." Given the "transient nature" of the condition, "the definition of asthma remains difficult to apply confidently in infants and preschool age children who present with recurrent episodes of coughing and/or wheezing" (Bacherier, 2008). The underlying pathophysiology is a chronic tissue inflammation of the airways that leads to impaired breathing. The condition is rooted in the immune system which overreacts in response to the presence of certain triggers. T-cell immunity remains a primary driver of inflammation as eosinophils, neutrophils and T cells enter the epithelium as an immune response, leading to inflammation. Many asthmatic children are atopic with a tendency to develop IgE antibodies and a Th1/Th2 imbalance in response to mitogens, allergens and viruses. A step-wise participation of most, if not all, components of the immune and inflammatory response, including T-cells, moncytes, eosinophils, cytokines, chemokines and arachidonic acid metabolites is common. Our understanding of the pathogensis of allergic disorders, including asthma, continues to grow rapidly with our increasing understanding of underlying immune-response (Kay, et.al, 2008). However, understanding the specific triggers for an individual is not always known.

Risk Factors. Research into risk factors suggest that genetic factors, environmental factors, lifestyle factors, infections, tobacco smoke, pollutants, nutrition, irritants, exercise, weather and stress (both the child's and the caregivers) are all associated with asthma. Evidence also suggests that concurrent triggers may may be

additive. Effective patient self-management, use of drug therapies and access to primary care can minimize asthma hospitalizations. Persistent asthma also remains most prevalent among children who are poor, non-hispanic black or in overall poorer health (Berry, 2011). High-risk profiles for asthma ICU readmissions include children who are overweight, non-caucasian and on public insurance (Carroll, 2010).

Diagnosis. Diagnosing and treating childhood asthma remains challenging with "no specific diagnostic tools or surrogate markers" for early detection in infants. Given the high prevelance and transient nature of coughing and wheezing in small infants and young children, diagnosis in younger children is usually only possible through long-term follow up and the child's respones to asthma treatment regimens. Case history, along with a physicial examiniation, allergy testing and chest x-rays are the most common tests used for diagnosing pediatric asthma. The most common measures of lung function include peak expiratory volume (PEF) and forced expiratory flow volume loop. Such measurement techniques are most useful in children above the ages of 5-6 years (Bacherier, 2008).

Treatment. Primary efforts aimed at managing asthma include removing the particular triggers that cause the allergic response. Evidence on the results of avoidance programs show conflicting results, particularly when weighed against the efforts required to maintain complete avoidance. However, avoidable allergens, including pets, dust, food , as well as triggers, like tobacco smoke, can be avoided with demonstrated benefit (Chan-Yeung, 2005). Pharmacological treatments include use of reliever and controller medications to manage symptoms and to reduce the risk of an episode. Reliever medications (also known as bronchodialators) include short acting inhaled β2 agonists and are used as a more immediate response to heightening symptoms. Beta-2 agonists interact with beta-2 receptors to stimulate expansion of bronchi. These treatments are generally administered through an inhaler or nebulizer.

Oral controller medications (corticosteroids) are used systemically the excesses of inflammatory response and reduce the risk of asthma exacerbations. Reaction to the use of these medications can differ widely by child given a number of risk factors (HHS, 2007). Immunotherapy is also a treatment for allergy-related exacerbations in an effort to reduce sensitization to known allergens over time. Self-management education has also been shown to improve outcomes (Bacherier, 2008).

Monitoring. Asthma is considered an Ambulatory Care Sensitive Condition (ACSC) (Barry, 2011) meaning that effective coordination of care may potentially reduce the incidence of hospitalization, ED visit and readmission. Condition monitoring remains important once diagnosed and is usually accomplished through primary and home care. Poor adherence to treatment regimens remains a common occurrence with rates ranging from 30-60% (Dekker, 1993; Gibson, 1995). Proper use of medications is key in preventing exacerbations (HHS, 2007). Ongoing lung function monitoring both at home and in a primary care setting are recommended as part of a written self-management plan (Bhogal, 2006).

Hospitalization. Hospitalization for asthma typically occurs when a child presents in the ER with a cough, wheezing and/or shortness of breath. ER and inpatient treatment for a potential asthma exacerbation involves use of bronchodilators and a regimen of corticosteroids to reduce inflammation and improve lung function (HHS, 2007). Patients are often admitted for observation or inpatient hospitalization until lung function improves and the child is maintaining good oxygen saturation levels without supplemental oxygen. Typical requirements for hospital discharge are: (1) stable breathing on room air with oxygen saturation rates in the 90s (2) reduced work of breathing and wheezing (3) tolerating oral medications and (4) stabilization of other co-morbid conditions.

Inpatient or observation length of stay for an asthma exacerbation is generally

characterized as a function of the time required to improve lung function so that the patient can function independently with the appropriate home care and outpatient medications. The time required to stabilize a patient can vary based upon a number of factors including patient overall health at admission, the presence of co-morbidities and the severity of asthma. Condition severity is further tied to patient factors noted above including genetic pre-disposition, environmental exposures and the effectiveness of previous patient self-management and treatment. Regarding the benefits of hospital care, the underlying assumption is that longer hospital stay may reduce the risk of relapse by providing a more complete treatment regimen of steroids/inhalers, more complete resolution of lung dysfunction, supplemental oxygen, opportunity for patient education on self-management/care, removal from the local environment that may be exacerbating the condition and better lung function.

STUDY HYPOTHESIS

Despite the existing research, estimating readmission risk remains a complex endeavor (Kansagara, 2011). Yet understanding both the underlying clinical and economic significance of readmissions, as well as identifying the underlying mechanisms available to impact readmissions, is essential to ensuring any reduction efforts are effective. One implicit assumption in efforts to reduce readmissions is that readmissions may result from an initial underutilization of hospital resources in providing care. Given this, our primary hypothesis was that an association exists between the general utilization of hospital resources and subsequent readmission risk for patients with asthma. Using length of stay as a surrogate for resource utilization (Silber, 2003), we tested the association between initial length of stay (ILOS) and readmission risk in pediatric asthma patients. We also examined the association between the difference in actual *vs.* expected length of stay and readmission risk. Understanding the potential

association between resource utilization and the probability of readmission might assist pediatric hospitals in evaluating cost-effective approaches to reducing readmissions.

MATERIALS AND METHODS.

Study Design. The study design was a retrospective, observational study using CHC MN hospital discharge data from January 2008 to August 2012. We chose the observational study design for several reasons. First, studies regarding readmissions in the pediatric population are limited (Gay, 2011). Use of the observational study design method was important in surveying the nature, frequency and potential risk factors associated with pediatric readmission as a foundation for further more detailed research. Second, the nature of the treatment itself (defined broadly as hospital length of stay) was outside the control of the researcher for practical reasons limiting the use of experimental methods. Finally, other potential research methods were not deemed practical given financial constraints. These factors, along with the availability retrospective data led to the design selection. The decision to use a retrospective observational study approach introduces certain study limitations that will be discussed later. While observational studies are not designed to provide definitive evidence of safety, efficacy or effectiveness, they can be useful in providing evidence of real world use and practice, developing future hypothesis for testing and informing clinical practice (Nahin, 2012).

Setting. MN Children's is a large, independent children's hospital system located in a large metropolitan area and acts as a safety net hospital, serving the needs of poorer, more diverse, multiracial and multilingual residents in the Twin Cities. Services include general inpatient, emergency and home health care, as well as specialty care, including ICU, NICU and Cardiac ICU. Children's hospital has about 13,000 discharges

annually along with 200,000 ER and outpatient visits. In reviewing hospital discharge activity for 2011, 57% of all discharges (80% of all asthma discharges) were from Hennepin, Ramsey and Dakota counties which include Minneapolis, St. Paul and the Southeast Twin Cities metropolitan area. This same area accounts for 38% of all children under the age of 17 per the 2010 Minnesota census (US Census Bureau, 2010).

Measurement Constructs. Specific measurement constructs to assist in the analysis are identified below:

- Hospital discharge - Hospital patient and transaction volumes are typically measured at the point of hospital discharge (i.e., when the patient is formally released from the hospital). For purposes of this study, both inpatient and observation stay discharges (stays under 24 hours) were included given their hospital resource impact and separately identified for sensitivity analysis (Macy, 2012).
- Length of stay (LOS) –Length of stay is defined as the difference between the discharge date and the admit date (date of discharge is not counted), measured as a whole number in days. Same day admits are counted as one day. Length of stay is generally considered a surrogate for measuring resource utilization and care (Silber, 2003).
- Total episode or incident of care – An episode of care is defined generally as the care given by a provider for a particular problem or condition over a set period of time. For purposes of this analysis, an "episode of care" is defined as the initial admit plus one additional subsequent admit within 30 days, if any. Only one readmit was associated with each admit. For episodes involving more than one readmit, the readmit becomes the index admit for the subsequent hospitalization. An episode of care was measured based upon the count (number of episodes) and duration (using

mean length of stay). This approach is consistent with other readmission research (Jencks, 2009).

- Index admission – Initial admission date for a given episode or incidence of care.
- Initial length of stay (ILOS) - Length of stay for an index admission.
- Expected length of stay (ELOS) – Median initial length of stay by severity level
- Non-elective readmission – Unscheduled inpatient readmissions to the hospital within a set timeframe from the index admission date. Estimates of truly preventable readmissions in the adult population vary from 5% - 79% of total readmissions (median 27%) (van Walraven, 2011). For purposes of this study, a readmission was defined as the first in-patient hospitalization (for reasons other than chemotherapy or radiotherapy) initiated within 30 days of discharge following a prior hospitalization.
- Premature hospital discharge – Any patient discharge with a length of stay less than an expected value, defined as the median length of stay for a given condition stratified by case severity. Readmissions could be for any condition and were not limited to asthma, though almost all readmissions following an inpatient hospitalization involving asthma were for respiratory-related conditions.
- Readmission rate – Total non-elective readmissions for the year divided by the total eligible inpatient discharges.
- Length of stay of an episode of care (Episode LOS) –Initial index length of stay plus length of stay of the subsequent readmission (Initial LOS + Readmit LOS).

Data Collection and Preparation. Hospital discharge data from January 2008 to August 2012 were drawn from the CHC MN Data Warehouse which is populated with medical and administrative data. Patient medical records were located on Cerner, the hospitals electronic health record system, a stable operating platform that has been in

place for 10 years. Demographic data were collected by patient, index admission and subsequent readmission. Readmissions were then linked to index admissions using the patient ID and discharge dates. Data drawn from the warehouse were aggregated and analyzed for general reasonableness.

Case Identification. As noted earlier, the spectrum of asthma, including multiple phenotypes, the natural history, the determinants, the triggers and pathophysiology can make clear diagnosis of the condition difficult. This can be made increasingly difficult as other non-asthma conditions can present with asthma-like symptoms or exacerbate an underlying asthma condition. Critical elements in making a proper diagnosis and treatment in younger patients, including a well-documented and accurate case history, may not always be readily available.

Use of the International Classification of Diseases, Ninth Revision, Clinical Modification (**ICD-9-CM**) principal diagnosis to identify asthma cases is a common practice in clinical research. Identification of asthma using either the principal or secondary diagnosis is more common when conducting public health research (Silber, 2003; Liu, 2009). Early in the review of asthma cases, it became clear that use of the ICD-9 principal diagnosis was potentially problematic and may have introduced a significant level of information bias into the results. Hospitals are incented through reimbursement guidelines to capture all conditions that the hospital may treat. However, to maximize recoveries, the principal diagnosis usually reflects the most resource-intensive treatment. Given that asthma is often a less resource-intensive condition than other respiratory conditions, this coding practice may lead to underreporting of asthma as the principal diagnosis despite its potential role in the hospitalization of the patient. Given the association between condition severity and readmission, failure to identify asthma-related hospitalizations when asthma is not the principal diagnosis may prevent the identification of more severe asthma cases coded under another principal diagnosis

category such as respiratory failure or pneumonia. Capturing a more complete population of probable asthma cases is increasingly important when measuring the impact of a particular condition on a hospital's resources for decision-making purposes.

To deal with the limitations involved in use of either the APR-DRG or ICD-9 classification schemes, a validation study was conducted to validate the identification of asthma cases from the discharge file based upon the identification of an ICD-9 code of asthma as one of the first five diagnosis code positions for respiratory conditions with a known association with asthma. A 2011 discharge population of potential asthma-related hospitalizations was drawn from the same children's hospital system using the ICD-9 CM code based upon the presence of an asthma diagnosis as one of the first five billing diagnosis (ICD-9-CM 493). After excluding sickle cell cases and RSV/bronchiolitis for patients less than 24 months, the cases were stratified by primary diagnosis for known associated respiratory conditions including asthma, pneumonia, respiratory failure and RSV/bronchiolitis (n=877). A random sample (n=87) was drawn from the population stratified by respiratory condition and diagnosis coding sequence. Identification criteria for asthma-related hospitalizations was developed through consultation with a hospital pulmonologist and focused on examining the underlying care process administered including a physician diagnosis of asthma, past history of asthma, use of relievers/corticosteroids upon admission/discharge with positive response and presence of an asthma discharge plan. A criteria-based medical record review was then conducted as a gold standard using this criteria to identify probable asthma cases.

A significant association was identified between the diagnosis coding sequence for asthma and detection of asthma-related hospitalizations beyond the principal diagnosis. The positive association was highest for asthma diagnosis codes in the second (89% of cases identified as asthma cases [95%CI: 0.68-.0.97]) and third coding positions (83% of cases identified as asthma cases [95%CI: 0.60-0.94]) before dropping

meaningfully for asthma diagnoses included in the fourth and fifth coding positions (21% of cases identified as asthma cases [95% CI: 0.09-0.44] and 36% of cases identified as asthma cases [95% CI: 0.16-0.62], respectively).

Based upon these results, we identified asthma cases for purpose of this study using a combination of the APR-DRG code/condition, asthma ICD-9 code position and patient age as noted in Table 1. For example, a five-year old male with pneumonia (coded to APR-DRG 139) with asthma as a secondary diagnosis in the second or third code position was included in the study. Applying this identification criteria to the more complete population of respiratory cases increased the identification of probable asthma-related hospitalizations 48% (n=1623 incremental cases). The use of the broader criteria lowered the estimated detection specificity and increased the estimated risk of false positive results (i.e., asthma was not a primary underlying reason for hospitalization) from 4% to 20%. A separate variable distinguishing asthma cases that were based upon the principal ICD-9 coding and those identified based upon coding of asthma in a secondary position was identified for purposes of sensitivity analysis.

Table 1 – Asthma case identification criteria

Principal Respiratory Diagnosis	APR-DRG Code	Asthma ICD-9 Code Position	Patient Age
Asthma	141	1-5	All
Pneumonia	139	2-3	All
Respiratory Failure	133	2-3	All
Respiratory Ventilation	130	All	All
RSV/Bronchiolitis	138	2-3	>24 mos

Statistical Methods. The primary statistical methods included both univariate and multivariate logistic regression to determine the association of the primary exposure

(ILOS) and the binary outcome (readmission). In analyzing the impact of ILOS on the risk of subsequent readmission, an initial descriptive analysis was performed to understand the population and to identify any differences in characteristics between discharges with and without a readmission. Categorical covariates were identified based upon known factors that may impact readmission including age (grouped by category), race, gender, language, hospital proximity (<> 5 miles), admit reason (asthma primary or secondary), discharge disposition (home or health agency), season of the year, procedure performed, (yes/no) severity of illness (using APR-DRG classification scale 1-4, with one being minor and 4 being extreme), payer (Commercial, Medicaid/State Assistance and Other) and year. Correlation testing was also performed between all possible covariates to determine the presence of any significant co-linearity amongst predictor variables. In an effort to identify any potential confounding or interaction variables, univariate logistic regression using a log-transformation was used to test the association between potential co-variates and length of stay. Length of stay is a discrete, numeric variable. LOS is positively skewed with a non-normal distribution making the distribution fit challenging. Researchers generally use a logarithmic transformation along with a data trimmed LOS to minimize the extreme values (Ruffieux, 1993).

To test the hypothesis that differences in actual *vs* expected initial length of stay may impact readmission risk, we measured the difference between actual and expected initial length of stay (expected initial length of stay was defined as the median length of stay set by category of severity). We grouped discharges into three categories: (1) those with an actual ILOS that equalled the expected ILOS, (2) those with an ILOS that was less than expected, and (3) those with an ILOS that exceeded the expected value. We then applied univariate and multiple logistic regression to measure the association

by category. We identified potentially significant covariates for further multivariate analysis .

All multivariate analysis was conducted using a step-wise regression to identify all significant covariates for purposes of the primary analysis. For multivariate regression purposes, candidate explanatory variables were identified using a p-value of 0.10. Model testing, including goodness of fit, area under the curve (AUC) and variance inflation factor (VIF) testing were performed as appropriate. All remaining tests were performed using an α=.05. All statistical analysis was performed using the statistical software Stata (Version 10.0; StataCorp, College Station, Tx).

RESULTS

Patient Population. The patient population included 4,965 patients discharged from CHC MN between January 1, 2008 and August 31, 2012 with an identified asthma diagnosis as defined. Among this population, we observed a readmission rate of 3.91% (n=194 readmissions). The CHC asthma population ranged from premature birth to adult with the majority of patients between 1-4 years of age (mean age 4.72 years). Sixty-one percent (61%) of patients were male which is generally consistent with a higher incidence of asthma among boys. Thirty-three percent (33%) of the cases were Black/African-American, including a relatively large population of recent African immigrants from Somalia (13.4% of the Black/African-American population declared Somali as their primary language – the actual number of Somali patients is probably higher). More than ninety percent (90%) of the patients discharged with asthma had mild to moderate asthma severity. Two thirds (66%) of asthma discharges were discharged with asthma as the primary diagnosis. Mean length of stay was 2.21 days (median ILOS 2 days).

Understanding Patient Demographics and Potential Risk Factors for Readmission. A complete demographic breakdown of the study population is noted in Table 2, including a univariate analysis of individual risk factors. Patient characteristics were generally consistent among those with and without a readmit. However, patients who were readmitted tended to be younger females with more severe conditions that may have required a procedure (i.e., usually mechanical ventilation). These patients were also more likely to be on public assistance. Significant risk factors for readmission in pediatric asthma patients identified through univariate regression analysis included case severity, age, procedure performed, season of the year and payer type. No significant collinearity was noted among risk factors ($r<0.7$).

Understanding Potential Risk Factors For Length of Stay. Log-transformed analysis was conducted to understand the association of potential explanatory variables on initial length of stay as noted in Table 3. Risk factors with a significant association to ILOS include age, gender, admit reason, patient type, severity, performance of a procedure, discharge disposition, season and payer type. Generally speaking, asthma patients with a longer mean length of stay tended to present in the winter months and were either very young (<1) or older (>10), female and on Medicaid. It was more likely that these patients had more severe cases and that asthma was not the recorded principal diagnosis. It was also more likely their treatment included a procedure.

Table 2 – Patient demographics and potential risk factors for readmission

	Description	n	% Total Population			Readmit Rate	OR (95% CI)
			Overall	No Readmit	With Readmit		
Discharge	Initial Discharge Asthma	4965				3.9%	
Age	Overall (Continuous)	4965	100.0%	100.0%	100.0%	3.9%	0.98 (0.95-1.02)
	<1	339	6.8%	6.4%	16.5%	9.4%	2.80 (1.84-4.26)
	1-4 year	2621	52.8%	53.0%	48.5%	3.6%	-
	5-9 yrs	1301	26.2%	26.5%	18.0%	2.7%	0.74 (0.50-1.10)
	10-14 yrs	525	10.6%	10.6%	9.3%	3.4%	0.95 (0.57-1.59)
	15-17 yrs	150	3.0%	2.9%	6.7%	8.7%	2.55 (1.39-4.63)
	18+ yrs	29	0.6%	0.6%	1.0%	6.9%	1.99 (0.47-8.49)
Race	White/Caucasian	1864	37.5%	37.6%	35.1%	3.6%	-
	Black/African-American	1641	33.1%	32.9%	35.6%	4.2%	1.16 (0.82-1.63)
	Other	1460	29.4%	29.4%	29.4%	3.9%	1.07 (0.75-1.54)
Gender	Female	1931	38.9%	38.7%	42.8%	4.3%	0.85 (0.63-1.13)
	Male	3034	61.1%	61.3%	57.2%	3.7%	
Language	English	4212	84.8%	84.9%	83.5%	3.8%	-
	Spanish	347	7.0%	7.0%	7.7%	4.3%	1.12 (0.66-1.94)
	Somali	233	4.7%	4.6%	6.7%	5.6%	1.47 (0.83-2.64)
	Other	173	3.5%	3.5%	2.1%	2.3%	0.59 (0.22-1.61)
Hospital Proximity	<5 miles	2273	45.8%	45.7%	47.4%	4.0%	1.07 (0.80-1.43)
	>5 miles	2692	54.2%	54.3%	52.6%	3.8%	
Admit Reason	Asthma Primary	3342	67.3%	67.2%	69.1%	4.0%	1.09 (0.80-1.48)
	Asthma Secondary	1623	32.7%	32.8%	30.9%	3.7%	
Patient Admit Type	Observation	881	17.7%	17.9%	13.4%	3.0%	0.70 (0.47-1.08)
	Inpatient	4084	82.3%	82.1%	86.6%	4.1%	
Admit Day	Weekday	3655	73.6%	73.5%	75.8%	4.0%	0.89 (0.64-1.24)
	Weekend	1310	26.4%	26.5%	24.2%	3.6%	
Case Severity	Minor (with observation stays)	1740	35.0%	35.2%	30.9%	3.4%	-
	Moderate	2757	55.5%	55.7%	52.1%	3.7%	1.06 (0.77-1.47)
	Major	440	8.9%	8.6%	16.0%	7.0%	2.12 (1.35-3.32)
	Extreme	28	0.6%	0.5%	1.0%	7.1%	2.15 (0.50-9.28)
Procedure	Procedure Performed	117	2.4%	2.2%	5.7%	9.4%	2.64 (1.40-5.01)
	No Procedure	4848	97.6%	97.8%	94.3%	3.8%	
Actual vs Expected ILOS	Acutal<Expected	857	17.3%	17.2%	19.1%	4.3%	1.21 (0.82-1.80)
	Actual=Expected	2396	48.3%	48.4%	44.3%	3.6%	-
	Actual>Expected	1712	34.5%	34.4%	36.6%	4.1%	1.16 (0.84-1.60)
Discharge Disposition	Home/Self-Care	4953	99.8%	99.7%	100.0%	3.9%	na
	Death/AMA	12	0.2%	0.3%	0.0%	0.0%	
Admit Season	Winter (Dec-Feb)	1075	21.7%	21.5%	25.3%	4.6%	2.06 (1.21-3.50)
	Spring (Mar-May)	1391	28.0%	28.0%	27.8%	3.9%	1.74 (1.03-2.94)
	Summer (Jun-Aug)	884	17.8%	18.1%	10.3%	2.3%	-
	Fall (Sep-Nov)	1615	32.5%	32.4%	36.6%	4.4%	1.99 (1.20-3.29)
Admit Year	2008	1051	21.2%	21.2%	20.1%	3.7%	-
	2009	1227	24.7%	24.7%	24.2%	3.8%	1.03 (0.67-1.59)
	2010	994	20.0%	20.0%	20.1%	3.9%	1.06 (0.67-1.66)
	2011	1009	20.3%	20.1%	25.3%	4.9%	1.32 (0.86-2.03)
Payer	Commercial	2176	43.8%	44.3%	33.0%	2.9%	-
	Medicare/Medicaid	2703	54.4%	54.0%	66.0%	4.7%	1.64 (1.20-2.23)
	None	86	1.7%	1.8%	1.0%	2.3%	0.79 (0.19-3.26)

The odds ratio measures the difference in readmission rates by characteristic. Reference values for categorical variables are noted with a "-" in the OR (95% CI) column.

Table 3 – Analysis of potential risk factors for length of stay

Risk Factor	Description	n	%	Mean ILOS	p-value
Discharge	Initial Discharge Asthma	4965	100.0%	2.21	
Age	<1	339	6.8%	2.51	-
	1-4 year	2621	52.8%	2.09	<.001
	5-9 yrs	1301	26.2%	2.12	<.001
	10-14 yrs	525	10.6%	2.69	0.394
	15-17 yrs	150	3.0%	2.41	0.990
	18+ yrs	29	0.6%	2.93	0.777
Race	White/Caucasian/Other	1864	37.5%	2.14	-
	Black/African American	1641	33.1%	2.23	0.102
	Other	1460	29.4%	2.27	0.004
Gender	Female	1931	38.9%	2.31	<.001
	Male	3034	61.1%	2.14	
Language	English	4212	84.8%	2.21	-
	Spanish	347	7.0%	2.21	0.771
	Somali	233	4.7%	2.15	0.391
	Other	173	3.5%	2.22	0.616
Hospital Proximity	<5 miles	2273	45.8%	2.18	0.505
	>5 miles	2692	54.2%	2.24	
Admit Reason	Asthma Primary	3342	67.3%	1.90	<.001
	Asthma Secondary	1623	32.7%	2.85	
Patient Admit Type	Observation	881	17.7%	1.10	<.001
	Inpatient	4084	82.3%	2.45	
Day	Weekday	3655	73.6%	2.24	0.089
	Weekend	1310	26.4%	2.11	
Severity	Minor (including observation stays)	1740	35.0%	1.44	-
	Moderate	2757	55.5%	2.39	<.001
	Major	440	8.9%	3.65	<.001
	Extreme	28	0.6%	9.32	<.001
Procedure	Yes	117	2.4%	6.63	<.001
	No	4848	97.6%	2.10	
Discharge Disposition	Home/Self Care	4953	99.8%	2.20	-
	AMA	7	0.1%	1.43	<.001
	Death	2	0.0%	8.00	<.001
	Other Facility	3	0.1%	6.67	<.001
Admit Season	Winter (Dec-Feb)	1075	21.7%	2.44	-
	Spring (Mar-May)	1391	28.0%	2.19	0.006
	Summer (Jun-Aug)	884	17.8%	2.09	<.001
	Fall (Sep-Nov)	1615	32.5%	2.13	<.001
Admit Year	2008	1051	21.2%	2.10	-
	2009	1227	24.7%	2.24	0.039
	2010	994	20.0%	2.20	0.324
	2011	1009	20.3%	2.33	0.100
Payer	Commercial	2176	43.8%	2.06	-
	Medicare/Medicaid	2703	54.4%	2.32	<.001
	None	86	1.7%	2.10	0.843

Reference values for testing significance of categorical variables noted in p-value column with '-'.
Admit year excludes partial year 2012 results.

Identification of Significant Covariates. The results of bivariate logistic regression identified four significant risk factors addressed in the final multivariate analysis: case severity, procedures, payer type and age. Similar testing of covariates associated with ILOS were also completed as noted in Table III. The results of this testing identified additional risk factors including gender, admit reason, admit type (observation vs inpatient) and season that were associated with ILOS. These risk factors are discussed briefly below.

Severity. Patients with a severity categorization of major were almost twice as likely to be readmitted as patients categorized as mild (2.12 [95% CI: 1.35-3.31]). More generally the risk of readmission increased as patient severity increased by category. The increase in severity was also associated with a significant increase in ILOS. Both factors suggest that severity may have either a a significant confounding or effect modification on the relationship between ILOS and readmission risk.

Other factors that may be associated with severity were also noted in examining ILOS. Season was shown to significantly impact ILOS with the highest mean LOS in the winter months and the lowest mean LOS in the summer months (2.44 vs 2.19 days; $p<.001$), consistent with other studies. Similarly significant differences in ILOS were noted for cases where asthma was the principal vs secondary diagnosis (1.90 vs 2.85 days; $p<.001$). Asthma not coded as the principal diagnosis suggests the increased presence of other comorbidities that can increase ILOS. Both the impact of seasonality and diagnosis on ILOS were also consistent with other study findings (Soyiri, 2011). Finally, the type of admission (observation vs inpatient stays) is directly associated with severity. For purposes of this study, all observation stays were classified as mild severity. Be definition, inpatient stays were significantly longer.

Procedures. The significant difference in readmission rates for procedures was not unexpected. Cases including the performance of a surgical procedure during stay

represented 2.2% of total cases in the population (n=117). The peformance of a procedure during the stay (almost by definition) is associated with increased case severity. Of the procedures performed, 58% involved non-invasive (n=25) or continuous (n=43) mechanical ventilation and 13% (n=15) involved a bronchial biopsy. Patients who had a procedure performed during their stay had a 2.5 times greater risk of readmission (OR 2.64 [95% CI: 1.40-5.01]) and had a significantly higher mean ILOS (4.53 day longer) than those that did not have a procedure.

Race and Payer Type. Despite the higher prevalence of asthma among non-hispanic black children in the hospital population, no significant direct differences in readmission rates by race were noted when comparing black/African-Americans (4.2%) with whites (3.8%) and other non-black minority groups (3.9%). Mean ILOS between black/African-Americans and whites was not significantly different which differs from the results of other studies which point to a correlation between race and LOS for asthmatic patients (Samuels, 1998; Soyiri, 2011). A significant difference was noted between whites and all other categories as grouped. Mean ILOS was higher among Asians, Native Americans and bi-racial groups relative to whites. Analyzing these groups individually, only Native Americans had a significantly different ILOS relative to whites (3.00 days vs 2.14 days ($p<.001$). The overall sample of identified Native Americans was relatively small (n=91).

Race is often linked to socio-economic status and payer type. This study did not find a strong correlation between race and payer type (r=.39). Medicaid/Medicare recipients had a significantly higher risk of readmission than commercial and self-insured patients (OR 1.64 [95% CI: 1.20-2.23]). Medicaid/medicare patients also had a longer mean LOS. The lack of a significant association between race and readmission or length of stay among Black/African-Americans may be the result, in part, of the characteristics of this specific population. This particular hospital discharge population

includes a significant number of recent African immigrants from Somalia who may possess distinctly different health characteristics than the African-American population in general. More research is needed to understand the impact of this distinct population.

Age. While age was not a significant risk factor for readmission when measured as a continuous variable, significant categorical differences were noted when grouped. Significant differences in readmissions rates were noted among children <1 yr of age as well as children 15+ years old relative to children between the ages of 1 and 15. Both these groups had a smaller sample of both admissions and readmissions (<1yr; admits n=309, readmits n=32; >15 yr admits n=179, readmits n=15). Children under 1 year old as well as children 10 years and above also had significantly higher mean LOS. In evaluating the results, the higher readmission rates among very young children (<1 yr) may be associated with the high prevelance of wheezing and other respiratory conditions among very young children due to continued lung and respiratory development, as well as diagnostic uncertainty associated with the condition in infants. For older children (15-17 years) the higher readmission rates may suggest that older children who continue to receive care at Childrens (vs another hospital) have more severe asthma including other co-morbidities and that patients are self-selecting to receive treatment at CHC MN. The other potential explanation for the higher readmission rates among older teens is that as children age, they take on more responsibility for managing their asthma care. Challenges with self-management of asthma care could also be impacting the readmission rates for older youth.

Gender. No significant differences in readmission rates were noted by gender. A significant difference in ILOS was identified based upon gender with females having a significantly higher mean ILOS than males (2.31 vs 2.14 days; p<.001). This is consistent with at least one recent study in the UK that identified a significantly higher LOS between females and males of all ages (1.11 times longer [95% CI: 1.09-1.13]).

Speculative reasons for the differences may include case severity, recovery timing or other factors. More research is needed to better understand the factors driving increased LOS in female asthma patients (Soyiri, 2011).

Evaluating ILOS and Readmission Risk. Univariate logistic regression analysis of ILOS (in days) indicated a 7% (OR: 1.07 [95%CI 1.02-1.12]) increased risk of readmission with each additional day a patient stays in the hospital. In multivariate analysis adjusting for risk factors including severity, payer type, procedure status and age, the association between ILOS and readmission risk remained positive at 3.6% but the results were no longer significant (OR: 1.04,[95%CI: .98-1.10]). Results of the multivariate analysis are summarized in Table 4. Pseudo r-square for the model was .0361. GOF testing was not significant (.8855). AUC measured at .650. VIF results showed no significant colinearity (all VIF <2).

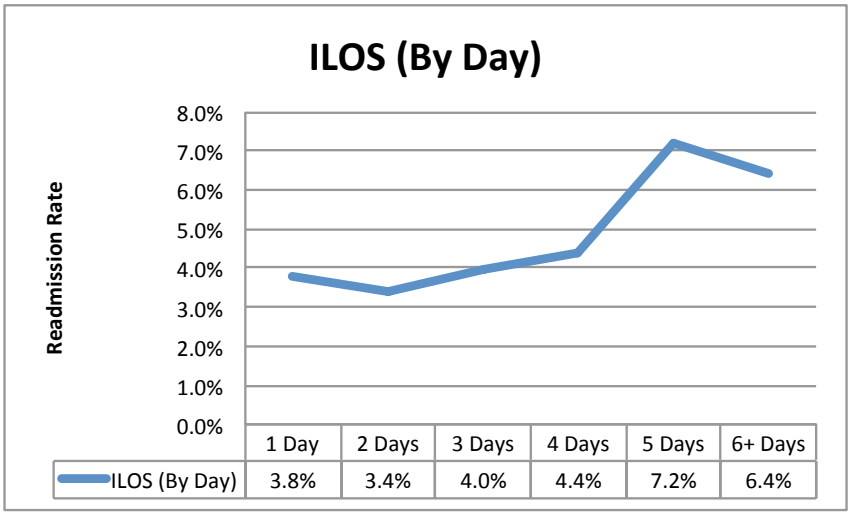
Table 4 – Final multivariate model results

	Odds Ratio	SE	z	P>|z|	95% CI	
					LL	UL
ILOS	1.04	0.03	1.15	0.25	0.98	1.10
Severity (vs mild severity):						
Moderate	0.98	0.17	-0.12	0.90	0.70	1.36
Major	1.71	0.42	2.17	0.03	1.05	2.76
Extreme	0.66	0.59	-0.46	0.64	0.12	3.74
Age group (vs age group 1-4):						
<1	2.58	0.55	4.39	0.00	1.69	3.93
5-9	0.72	0.15	-1.63	0.10	0.48	1.07
10-14	0.88	0.23	-0.50	0.62	0.52	1.47
15-17	2.52	0.78	2.97	0.00	1.37	4.64
18+	1.61	1.21	0.63	0.53	0.37	6.99
Payer (vs commercial payer):						
Medicare/Medicaid	1.59	0.25	2.97	0.00	1.17	2.18
None	0.92	0.67	-0.11	0.92	0.22	3.87
Procedure	1.89	0.73	1.65	0.10	0.89	4.04

Reference values for categorical variables are noted in parenthesis.

Evaluating ILOS and Readmission Risk Categorically By Day. Further analyzing ILOS categorically by day, one-day stays had an increased risk of readmission (OR: 1.27[95% CI: 0.87-1.85]) over two-day stays, which had the lowest overall readmission rate. Observed differences in readmission rates were not significant. The observed readmission rate increased slightly as ILOS extended beyond two days as noted in Figure 1, but that increased rate was not statistically different from the readmission rate for discharges with an ILOS of two days (OR= 1.68[95% CI: 0.82-3.46]).

Figure 1 – Readmission rate by initial length of stay (in days)



Similarly, the readmission rate for a one-day length of stay was slightly higher but that observed difference was well within confidence limits when compared with the median 2-day ILOS as noted in Table 5.

Table 5 – Final multivariate results categorized by day

	Description	n	% Total Population			Readmit Rate	Adjusted OR 95% CI
			Overall	No Readmit	With Readmit		
	Overall	**4965**	**100.0%**	**100.0%**	**100.0%**	**3.9%**	**1.04 [0.98-1.10]**
ILOS (by Category)	1 Day	1870	37.7%	37.7%	36.6%	3.8%	1.27 [0.87-1.85]
	2 Days	1736	35.0%	35.1%	30.4%	3.4%	-
	3 Days	727	14.6%	14.6%	14.9%	4.0%	1.07 [0.68-1.70]
	4 Days	321	6.5%	6.4%	7.2%	4.4%	1.11 [0.60-2.04]
	5 Days	139	2.8%	2.7%	5.2%	7.2%	1.68 [0.82-3.46]
	6+ Days	172	3.5%	3.4%	5.7%	6.4%	1.11 [0.53-2.35]

The odds ratio measures the difference in readmission rates by day with the median ILOS of 2 days as the reference category.

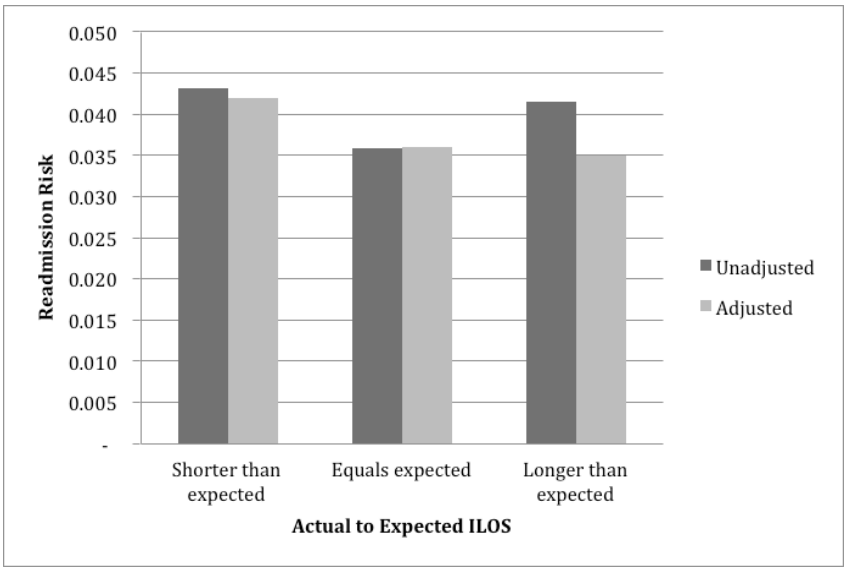
Testing for Effect Modification. We stratified our sample by category of severity in order to test for effect modification. The readmission risk associated with length of stay differed by severity level but was not significant on both an unadjusted and adjusted basis as noted in Table 6.

Table 6 – Impact of ILOS on readmission risk by severity level

	Unadjusted		Adjusted	
Level	**ILOS OR**	**95% CI**	**ILOS OR**	**95% CI**
Mild	0.88	.60-1.29	0.82	.55-1.21
Moderate	1.09	.96-1.23	1.00	.88-1.15
Major	0.97	.84-1.12	0.93	.79-1.09
Extreme	1.09	1.00-1.19	na	na

Assessing Expected vs Actual Length of Stay and Readmission Risk. To refine our measurement of possible early hospital discharge, we compared the actual to expected length of stay by readmission type, adjusting for severity. We found that patients who were discharged as expected (the difference in actual vs expected ILOS was zero) had the lowest observed readmission risk (3.6%). Patients who were released either earlier or later than expected had a higher readmission risk (OR: 1.21 [95% CI: 0.82-1.79]) and (OR: 1.16 [95% CI: 0.84-1.60]), respectively, than those released as expected as noted in Figure 2. However, the associations were not significant. Though the observed value dropped for patients released later than expected, the lack of a statistical association remained upon further adjusting for known covariates (actual<expected - OR: 1.13 [95% CI: 0.74-1.71]; actual>expected - OR: 0.97 [95% CI: 0.69-1.38]).

Figure 2 - Observed readmission risk by difference in actual vs expected ILOS



DISCUSSION

Our study objective was to determine what association may exist between initial hospital resource utilization and the risk of readmission. To test this, we evaluated two measurements of hospital resource utilization. The first measurement looked at ILOS more generally and by day. The second measurement categorized patients into three subgroups based upon whether their ILOS was shorter than, in line with or longer than the expected ILOS.

Contrary to our initial expectations, after adjusting for known confounders, we found no significant association between ILOS and readmission risk (OR: 1.04 [95% CI: 0.98-1.10]). These findings are similar with at least one study on the adult population that found that increasing LOS did not affect the likelihood of readmission across all conditions (Johnson, 2012). One study of readmission risk factors among inner-city children in the Bronx with asthma also found no association between ILOS and readmission risk (OR 1.08 [95% CI: 0.97-1.21]) (Reznick, 2006).

The lack of association between ILOS and readmission risk could also be seen analyzing LOS categorically by day. The difference in risk for different values of LOS was not statistically different from the risk of readmission for the median LOS of two days. In categorically analyzing the association between the difference in actual vs expected length of stay, we found that the observed difference in readmission risk for patients was highest for those that had either a shorter or longer than expected ILOS, but the association was not significant. This lack of association remained after adjusting for covariates, indicating that patients who were released earlier than anticipated did not have a significantly different risk of readmission.

These findings have several implications. First, use of the ICD-9 principal diagnosis code or the APR-DRG code for asthma detection understates the real burden of asthma within a hospital population. Early in the review of asthma cases, we found the use of the ICD-9 principal diagnosis introduced information bias into the results. Hospitals are incentivized through reimbursement guidelines to capture all conditions that the hospital treats during a patients stay. However, to maximize payments, the principal diagnosis usually reflects the most resource-intensive treatment. Given that asthma may be less resource-intensive than respiratory failure or other conditions, this can lead to underreporting of asthma as the principal diagnosis despite clear evidence of asthma treatment and its major role in the illness. With a higher mean ILOS (2.85 days *vs.* 1.90 days; $p<.001$) for asthma cases with a secondary ICD-9 diagnosis, capturing the more complete population of treated asthma cases increased the number of asthma patient days 4625 or 73%. Assuming a daily charge of $5000, the potential financial scope of asthma-related hospitalizations would increase meaningfully in this population from $6.8M to $11.8M annually, increasing the potential impact of efforts to reduce asthma hospitalizations.

Second, overall asthma readmission levels are relatively low when compared to the adult asthma population. The CHC MN readmission rate of 3.91% we measured over four years is generally consistent with national data which estimated pediatric asthma readmissions at 3.2%, This is in contrast to adult asthma 30-day readmission levels that range from 11.8% to 17.3%, increasing with age (Jencks, 2009; HHS, 2013). This suggests that the opportunity to lower cost and improve outcomes through reducing readmissions is much lower in the pediatric population than in the adult population.

Third, the lack of association between ILOS and readmission risk suggests that days counted in an episode of care length of stay are not exchangeable. As a result, altering initial length of stay in an effort to reduce the risk of readmission will likely have a limited impact in reducing episode of care length of stay for pediatric asthma patients. For example, based upon our findings, increasing all one-day visits in the study to two-day visits would increase hospital patient days by 38% in this cohort (1870 days) while decreasing total readmissions by only 3.8% [95% CI: 3.6-4.0%]. This translates into 1870 additional days to eliminate 7 readmissions with a savings of 18-20 days of readmit length of stay, resulting in a net increase of 1850 days of hospitalization.

STUDY LIMITATIONS

Several factors may impact the internal and external validity of study results.

Use of Observational Study Methods. Use of an observational study method can increase the risk of potential confounding compared to the use of experimental methods. Efforts to assess and minimize the impact of potential confounding factors were addressed through a detailed analysis of known confounding factors for association with the exposure and outcome variables.

Single Hospital System. Approximately 25% of children's hospitalizations in the US are at children's hospitals (Marenstein, 2005). This study was conducted within a

single independent children's hospital system with a set of potentially distinct characteristics from general hospitals including the urban setting, patient demographics, the nature and severity of conditions treated and any distinct asthma treatment protocols or clinical pathways in place. Evidence suggests that median LOS may not vary significantly between childrens hospitals and general hospitals though study results are mixed (Muerer, 1999; Marenstein, 2005). Patterns of care and readmission rates for asthma between children's hospitals and general hospitals in the NY/PA region were shown to be consistent after adjusting for certain covariates (Silber, 2003). Care should be taken in applying these results more generally across the pediatric population.

Case Identification Methods. The identification of asthma cases including respiratory cases with a secondary diagnosis code of asthma increased the sensitivity and overall accuracy in detecting asthma cases, but also lowered the detection specificity and increased the accuracy of case identification from 52% to 83%. The risk of false positive results increased from 4% to 20%. Given the volume and nature of asthma cases excluded through use of the primary diagnosis code alone, use of the refined criteria led to a more complete count and seemed a reasonable trade-off to obtain a better measure of the impact of asthma on hospital resources.

Other Known Confounding Factors. Known confounding factors identified in adult readmission studies include readmission to a different hospital, the nature of post-discharge primary care, medical indigence and discharge against medical advice (DAMA) (Ashton, 1996). The incidence of DAMA was immaterial (n=7, 0.14%). Regarding medical indigence, 1.7% of identified cases had no insurance. While the percentage of children covered by insurance was higher than for the general adult population in Minnesota, the percentage of children with coverage is significantly lower than the approximately 6.1% of children in Minnesota without insurance (CDF, 2012).

Uninsured patients have been shown to have distinct demographic characteristics that are not fully addressed in this study.

Selection Bias and Loss To Follow Up. Readmission to a different hospital may also introduce study bias given that asthma patients readmitted to CHC MN self-select for readmission and may be lost to follow up. This could lead to understating the true readmission rate related to hospital care in the population and remains a challenge in readmission studies. To estimate the potential impact of CHC MN discharges readmitted to a different hospital within 30 days, a CHC MN preliminary analysis using data for 2011 (n=207 readmits) from a local payer determined that 10% of these cases readmitted for all causes were readmitted to a non-CHC MN hospital. Increasing the actual readmission volume by 10% did not materially change the calculated readmission rate of 3.91% (95% CI 3.36-4.44%). Given that children treated at childrens hospitals have a higher prevalence of single or multiple complex co-morbid conditions (Marenstein, 2005; Silber 2003), cases being readmitted to CHC MN may have characteristics that differ from those who seek readmisson elsewhere and thus were not included as readmissions. As a result, the overall readmission rate for this study may be understated and the case mix associated with readmissions as part of this study may differ from the general population.

CONTRIBUTION AND FUTURE DIRECTIONS

Understanding pediatric readmissions remains a complex endeavor. The primary contribution of this study is to demonstrate that no strong association exists between initial length of stay as a measure of hospital resource utilization and the risk of readmission for pediatric asthma patients. More research is needed to further validate these results across multiple centers. These findings have potential implications for both payers and hospitals working to implement accountable care programs. Given the

significantly lower readmission rates for pediatric care, payors may need to re-examine the use of readmissions as an impactful measure of inpatient hospital care for childhood conditions such as pediatric asthma. Other factors outside hospital care, such as environment, condition severity, and so forth, have a more significant impact on readmission risk than the quantity of inpatient care and should be examined in setting separate incentive policies for childrens hospitals (Morse, 2011).

Researchers have argued that preventing rehospitalizations for pediatric asthma requires a more concerted effort by hospitals to influence those factors that can change behavior outside the hospital, beginning with better coordination between the hospital and the primary care organizations (Vest, 2010; Feigenbaum, 2012) and improved patient self-management (Reindal, 2006). Research should be done to evaluate how quantitative discharge guidelines aimed at lowering readmissions can be embedded into an electronic health record (EHR) checklist as part of the discharge planning process to identify potential high-risk patients for follow up care. Targeted, innovative uses of technology to improve primary care coordination and better monitor patient self-care following discharge should be further examined as a potentially more cost-effective method for minimizing readmission risk.

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