Association of Bronchiolitis Clinical Pathway Adherence With Length of Stay and Costs

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abstract

OBJECTIVES: To examine the associations between the level of adherence to bronchiolitis clinical pathway recommendations, health care use, and costs.

METHODS: We conducted a retrospective cohort study of 267 patients ≤24 months old diagnosed with bronchiolitis from 12/2009 to 7/2012. Clinical pathway adherence was assessed by using a standardized scoring system (0–100) for 18 quality measures obtained by medical record review. Level of adherence was categorized into low, middle, and high tertiles. Generalized linear models were used to examine relationships between adherence tertile and (1) length of stay (LOS) and (2) costs. Logistic regression was used to examine the associations between adherence tertile and probability of inpatient admission and 7-day readmissions.

RESULTS: Mean adherence scores were: ED, 78.8 (SD, 18.1; n = 264), inpatient, 95.0 (SD, 6.3; n = 216), and combined ED/inpatient, 89.1 (SD, 8.1; n = 213). LOS was significantly shorter for cases in the highest versus the lowest adherence tertile (ED, 90 vs 140 minutes, adjusted difference, –51 [95% confidence interval (CI), –73 to –29; P <.05]; inpatient, 3.1 vs 3.8 days, adjusted difference, –0.7 [95% CI, –1.4 to 0.0; P <.05]). Costs were less for cases in the highest adherence tertile (ED, –$84, [95% CI, –$7 to –$161; P <.05], total, –$1296 [95% CI, –126.43 to –2466.03; P <.05]). ED cases in the highest tertile had a lower odds of admission (odds ratio, 0.38 [95% CI, 0.15–0.97; P < .05]). Readmissions did not differ by tertile.

CONCLUSIONS: High adherence to bronchiolitis clinical pathway recommendations across care settings was associated with shorter LOS and lower cost.

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WHAT'S KNOWN ON THIS SUBJECT: Clinical practice guidelines and clinical pathways may reduce resource use and within-hospital variation for inpatient care for children admitted for bronchiolitis. The relationship between adherence to pathway processes of care and health care use outcomes has not previously been studied.

WHAT THIS STUDY ADDS: This study demonstrates that, for children with bronchiolitis, higher adherence to standardized clinical processes of care is associated with decreased length of stay and decreased costs in the pediatric emergency department and inpatient settings.

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Bronchiolitis is the leading cause of infant hospitalization in the United States, with direct medical costs exceeding 500 million dollars annually.[1–4] Evidence suggests that hospital-based care for bronchiolitis should primarily be supportive and that laboratory testing (eg, viral respiratory panels) and medications, including bronchodilators, corticosteroids, and antibiotics, do not improve outcomes.[1,5–10] Consequently, many hospitals have implemented clinical practice guidelines (CPGs) and clinical pathways to decrease variability in care and unnecessary use of interventions as a mechanism to decrease costs.

Previous studies have examined the effectiveness of CPGs and clinical pathways on inpatient bronchiolitis processes of care.[11–16] Although CPGs and clinical pathways within institutions appear to reduce resource use for bronchiolitis, there continues to be wide practice variation for inpatient bronchiolitis care across institutions.[4,11,17,18] Studies to date have not compared the impact of adherence to specific care processes within bronchiolitis pathways on health care outcomes, limiting our understanding of how extensively pathways are implemented and applied to each individual patient.[19] Our objective was to evaluate the impact of adherence to standardized clinical processes of care for bronchiolitis on health care use and costs in the pediatric emergency department (ED) and inpatient settings.

METHODS

Study Population

We conducted a retrospective analysis of 267 patients admitted with an exclusive discharge diagnosis of bronchiolitis to Seattle Children's Hospital (SCH), a free-standing academic children's hospital that serves as a referral center for 5 states, from December 1, 2009 to July 31, 2012. Cases were identified from the Pediatric Hospital Information System database by using the *International Classification of Diseases, Ninth Edition, Clinical Modification* (ICD-9) codes for bronchiolitis (466.1X). Fifty-one cases were seen in the ED only and not admitted. Three cases were directly admitted to the inpatient setting only and not seen in the ED. The remaining 213 cases were treated in both the ED and inpatient settings. Patients' ages ranged from 0 to 24 months. We only included cases that had an exclusive ICD-9 discharge diagnosis of bronchiolitis to ensure a relatively healthy sample of children with bronchiolitis. During medical record review, included cases were later excluded if they had any history of cardiac disease requiring baseline medication, anatomic airway abnormalities, reactive airway disease or asthma at ≥12 months of age, cystic fibrosis, neuromuscular disease, bronchopulmonary dysplasia, immunodeficiency, or chronic lung disease. The SCH Institutional Review Board approved this study.

Determining Level of Adherence to Bronchiolitis Clinical Pathway

The level of adherence to the bronchiolitis clinical pathway was determined by using the Pediatric Respiratory Illness Measurement System (PRIMES) quality indicators developed by Mangione-Smith et al.[20] PRIMES is a set of process of care quality indicators that can be used to assess the clinical management of pediatric respiratory conditions, including bronchiolitis. PRIMES was developed based on a review of current literature and clinical practice guidelines and validated by using the Rand/University of California, Los Angeles–modified Delphi method.[21] Detailed measure specifications were created for each quality indicator and used in the development of a standardized electronic medical record abstraction and scoring tool.

We first identified PRIMES quality indicators that corresponded to specific processes of care in the SCH bronchiolitis clinical pathway. This process was done in a collaborative and iterative manner by the medical record abstractors and the authors. The SCH bronchiolitis clinical pathway was originally developed in 2003 by a multidisciplinary team of physicians, respiratory therapists, and nursing leadership. Pathway implementation entailed the development of a clinical guideline of care and order set, dissemination through grand rounds, and consistent review of metrics by using Pediatric Hospital Information System data. Thus, the pathway was well established and underwent no changes in clinical content during the study period (December 1, 2009–July 31, 2012). In 2013, the pathway was updated secondary to the introduction of high-flow nasal cannula therapy for patients with bronchiolitis.

Of the 21 PRIMES indicators, 18 that corresponded with clinical pathway care recommendations were included (Supplemental Table 5). Of the 3 indicators that were not included, 2 were excluded because there was no pathway recommendation that corresponded to the PRIMES indicator. The third excluded indicator concerned the use of chest radiographs. The pathway and PRIMES recommendations were in agreement that chest radiographs should not routinely be obtained; however, the exception criteria of when to obtain a chest radiograph differed between the pathway and PRIMES. Therefore, determining adherence to the PRIMES indicator for when to obtain a chest radiograph did not necessarily reflect adherence to the SCH clinical pathway.

The PRIMES indicators are intended for use either in the ED or inpatient setting. Six of the included indicators

applied to the ED setting and 12 applied to the inpatient setting. Adherence to the PRIMES indicators was determined by medical record review. For each case, 2 trained research nurses performed medical record abstractions using the PRIMES tool to determine if the patient met eligibility criteria for each PRIMES bronchiolitis indicator (denominator) and whether the patient received the indicated care (numerator). There was high interrater reliability between the abstractors with a κ value of 0.9 for determining eligibility and 0.8 for determining receipt of indicated care. The level of adherence to the clinical pathway was determined by computing 3 scores for each case: (1) an ED adherence score, calculated as the number of quality indicators met divided by the number they were eligible for across the 6 ED quality indicators; (2) an inpatient adherence score, calculated as the number of indicators met divided by the number they were eligible for among the 12 inpatient quality indicators; and (3) a combined ED/inpatient adherence score, calculated as the number of indicators met divided by the number they were eligible for across all 18 quality indicators. Scores were standardized on a 0 to 100 scale, with higher scores reflecting better adherence to the pathway.

Outcomes

We examined the association between the level of adherence to the bronchiolitis clinical pathway and the following outcomes: ED and inpatient length of stay (LOS), ED and inpatient costs, inpatient admission, 7-day return ED visits, and 7-day inpatient readmissions. Total charges for each case, including pharmacy, laboratory, radiology, and respiratory therapy, were obtained from hospital administrative records. Charges were converted to total costs by using institutional cost-to-charge ratios based on admission fiscal year. Costs for ED care, radiology, pharmacy, and laboratory were calculated by using department-specific cost-to-charge ratios by fiscal year. All costs were inflation adjusted to 2014 US dollars by using the medical care services component of the Consumer Price Index.[22]

Statistical Analysis

We compared differences in health care use and cost for varying levels of pathway adherence. We divided cases into tertiles based on their ED, inpatient, and combined ED/inpatient adherence summary scores and compared cases in the lowest tertile to those in the highest tertile. Multivariate generalized linear models were used to examine associations between adherence score tertiles and outcomes for 3 different subsamples of cases: those receiving ED care (n = 264), those receiving inpatient care (n = 216), and those receiving care in both settings (n = 213). For those receiving ED care, we examined associations between ED adherence score tertiles and: (1) ED LOS and (2) ED cost. For those receiving inpatient care, we examined associations between inpatient adherence score tertiles and: (1) inpatient LOS and (2) inpatient costs. For cases receiving care in both settings, we examined associations between ED, inpatient, and combined ED/inpatient adherence score tertiles and: (1) inpatient LOS, (2) total cost, and (3) department-specific costs. LOS and cost variables were truncated at the 99th percentile to prevent the skewed distribution from distorting SEs in the multivariate analyses. Observations above the 99th percentile were assigned the 99th percentile value; this occurred for 3 LOS and 3 cost observations. Multivariate logistic regression was used to examine associations between ED adherence score tertiles and 7-day ED return visits and inpatient readmissions, adjusting for age, triage acuity, and medical complexity. Multivariate logistic regression was used to examine associations between combined ED/inpatient adherence score tertiles and 7-day inpatient readmissions, adjusting for age and medical complexity.

Covariates

The following covariates were included: age, medical complexity, ED triage acuity, admission season, and, for ED outcomes, whether the case was admitted to the inpatient setting. Models predicting total cost were adjusted for inpatient LOS dichotomized as ≤3 days and >3 days. Medical complexity was assessed by using the Pediatric Medical Complexity Algorithm (PMCA).[23] This algorithm classifies children into 3 categories: without chronic disease, noncomplex chronic disease, and complex chronic disease, based on hospital discharge administrative ICD-9 billing codes. ED triage acuity was assigned to each patient by a trained nurse on presentation to the ED by using the Emergency Severity Index from the Agency of Healthcare Research and Quality as part of standard clinical practice with the following categories in decreasing level of severity: critical, emergent, urgent, nonurgent, and minor.[24] The admission month was adjusted for so as to account for seasonal trends and was categorized as high (November through March), and low viral illness season (April through October).[25] We conducted medical record review for all cases classified by PMCA as noncomplex or complex chronic disease (N = 49) to ensure they met eligibility criteria for the study. We conducted a Pearson's χ^2 test of the adherence score tertile distribution by categorical age (< or ≥1 year).

RESULTS

Demographics

Children in the highest adherence tertile had a significantly younger

TABLE 1 Patient Demographic Characteristics Overall and by Adherence Score Tertile

	All Patients $N = 267$	Highest Adherence Score Tertile $N = 71$	Lowest Adherence Score Tertile $N = 71$
Mean age, mo (SD)[a]	7.8 (5.6)	6.1 (5.2)	8.1 (5.9)
Sex (%)			
Girl	43	42	45
Boy	57	58	55
Race (%)			
White	48	61	48
African American	9	7	13
Hispanic	22	15	20
Asian	8	3	7
Other	13	14	12
Triage acuity (%)[b]			
Emergent	19	20	28
Urgent	66	75	66
Nonurgent	16	6	6
PMCA[23] (%)			
Nonchronic	81	83	79
Noncomplex chronic	17	16	18
Complex chronic	2	1	3
Season (%)			
High (November–March)	80	70	77
Low (April–October)	20	30	23

Sums may not equal 100% due to rounding.
[a] Significant difference between adherence categories; $P < .05$.
[b] Triage acuity is based on the Emergency Severity Index.[24]

mean age compared with those in the lowest tertile (Table 1). There were no significant differences in the distribution of sex, race/ethnicity, medical complexity, triage acuity, seasonality, or categorical age by adherence tertiles.

Adherence Summary Scores

Adherence scores by tertile are presented in Table 2. Adherence was highest for the inpatient quality indicators (mean score, 95.0 [SD, 6.3]) and lowest for the ED quality indicators (mean score, 78.8 [SD, 18.1]).

LOS

Mean ED LOS was significantly shorter for cases with ED adherence scores in the highest versus the lowest tertile (Table 3). There were no significant differences in mean inpatient LOS by inpatient adherence score tertiles ($n = 216$). For cases receiving care in both the ED and inpatient settings, there was no association between their ED adherence score tertiles and inpatient LOS or their inpatient adherence score tertiles and inpatient LOS ($n = 213$). However, the mean inpatient LOS was ~17 hours shorter for cases with combined ED/inpatient adherence scores in the highest compared with the lowest tertile (Table 3).

Cost

Mean ED costs for cases with ED adherence scores in the highest tertile were significantly lower than cases with scores in the lowest tertile (Table 4). There were no significant differences in mean total costs by inpatient adherence score tertile. For cases receiving care in both the ED and inpatient settings, there was no association between their ED adherence score tertiles and total costs or their inpatient adherence score tertiles and total costs. However, for cases where the combined ED/inpatient adherence scores were in the highest tertile, the mean total costs were significantly lower than for cases with combined adherence scores in the lowest tertile (Table 4). For these combined cases with adherence scores in the highest tertile, we found significantly lower costs resulting from laboratory testing, radiographic studies, and respiratory therapy, but no significant differences in pharmacy costs when compared with those cases in the lowest tertile (Table 4).

Inpatient Admission, 7-day ED Return Visits and Readmissions

Cases with ED adherence scores in the highest tertile had a lower odds of inpatient admission compared with those with scores in the lowest tertile (odds ratio, 0.38 [95% confidence interval [CI], 0.15 to 0.97]) adjusted for age, triage acuity, medical complexity, and seasonality. Only 5 cases had return ED visits

TABLE 2 Mean Adherence Scores by Tertile

	All Patients		Highest Adherence Score Tertile		Lowest Adherence Score Tertile	
	N[a]	Mean (SD)	N	Mean (SD)	N	Mean (SD)
ED scores	264	78.8 (18.1)	91	95.3 (4)	91	58.9 (15.6)
Inpatient scores	216	95.0 (6.3)	73	99.7(0.2)	69	87.2 (5.1)
Combined ED and inpatient scores	213	89.1 (8.1)	71	97 (2)	71	79.5 (5.9)

[a] Fifty-one cases were treated in the ED only; 3 cases were treated in the inpatient setting only. Combined includes only patients who were seen both in the ED and inpatient setting during this hospitalization.

TABLE 3 Adjusted Associations Between Adherence Score Tertiles and LOS Outcomes

Outcome	*n*[a]	Adherence Tertile	Adjusted (95% CI)	Adjusted Difference (95% CI)
ED LOS (min)	264	High ED	90 (50 to 129)	−51* (−73 to −29)[b]
		Low ED	140 (99 to 182)	
Inpatient LOS (d)	213	High ED	3.1 (2.3 to 4.0)	−0.5 (−1.1 to 0.2)[c]
		Low ED	3.6 (2.7 to 4.5)	
Inpatient LOS (d)	213	High IP	3.6 (2,7 to 4.5)	0.3 (−0.4 to 0.9)[c]
		Low IP	3.3 (2.4 to 4.2)	
Inpatient LOS (d)	213	High combined ED/IP	3.1 (2.2 to 3.9)	−0.7* (−1.4 to −0.0)[c]
		Low Combined ED/IP	3.8 (2.9 to 4.6)	

IP, inpatient.

[a] Cases with ED care who were discharged from the hospital or admitted: *n* = 264; cases admitted to the inpatient setting from the ED: *n* = 213.

[b] Adjusted for age, medical complexity, triage acuity, seasonality, and whether the patient was admitted to the inpatient setting.

[c] Adjusted for age, medical complexity, triage acuity, and seasonality.

* $P < .05$.

TABLE 4 Adjusted Associations Between Adherence Score Tertiles and Cost Outcomes

Outcome	*n*[a]	Adherence Tertile	Adjusted (95% CI)	Adjusted Difference (95% CI)
ED cost	264	High ED	$615.64 (477.17 to 754.10)	−$84.29* (−161.50 to −7.07)[b]
		Low ED	$699.92 (554.30 to 845.54)	
Inpatient cost	216	High IP	$3751.49 (2418.35 to 5084.63)	$69.28 (−1101.14 to 1239.69)[c]
		Low IP	$3682.21 (2234.65 to 5129.77)	
Total cost	213	High ED	$7720.14 (5730.06 to 9728.23)	−$1020.71 (−2578.26 to 536.84)[c]
		Low ED	$8749.85 (6720.87 to 10 778.84)	
Total cost	213	High IP	$4851.81 (3482.31 to 6.220.31)	$82.22 (−1.105.97 to 1270.42)[c]
		Low IP	$4769.68 (3299.89 to 6239.28)	
Total cost	213	High combined ED/IP	$4446.13 (3158.84 to 5733.41)	−$1296.23* (−2466.03 to −126.43)[c]
		Low combined ED/IP	$5742.35 (4290.46 to 7194.25)	
Respiratory therapy cost	213	High combined ED/IP	$45.95 (−128.75 to 220.65)	−$166.27* (−315.57 to −16.98)[c]
		Low combined ED/IP	$212.22 (36.90 to 387.54)	
Pharmacy cost	213	High combined ED/IP	$136.60 (14.87 to 258.32)	$36.55 (−74.07 to 147.16)[c]
		Low combined ED/IP	$100.05 (−37.24 to 237.34)	
Radiology cost	213	High combined ED/IP	$27.34 (−3.36 to 58.03)	−$56.17* (−90.12 to −22.21)[c]
		Low combined ED/IP	$83.50 (49.13 to 117.87)	
Laboratory cost	213	High Combined ED/IP	$217.61 (159.42 to 275.80)	−$103.93* (−168.30 to −39.56)[c]
		Low combined ED/IP	$321.54 (256.38 to 386.70)	

All costs are reported in 2014 dollars. IP, inpatient.

[a] Cases with ED care who were discharged from the hospital or admitted: *n* = 264; cases admitted to the inpatient setting from the ED: *n* = 213; cases admitted to the inpatient setting either directly or through the ED: *n* = 216.

[b] Adjusted for age, medical complexity, triage acuity, seasonality, and whether the patient was admitted to the inpatient setting.

[c] Adjusted for age, medical complexity, categorical length of stay, and seasonality.

* $P < .05$.

within 7 days and 6 had inpatient readmissions. There were no significant differences in the odds of return ED visits or readmissions by adherence score tertile.

DISCUSSION

In this retrospective cohort of otherwise healthy children with bronchiolitis, we examined the association between adherence to an evidence-based clinical pathway and health care use outcomes and cost. Overall, we found shorter LOS and lower costs in cases with higher adherence to the clinical pathway across the ED and inpatient settings. There were lower odds of inpatient admission for cases with high adherence to the ED pathway processes of care. Despite shorter LOS and lower risk of admission, there was no difference in the odds of return ED visits or inpatient readmission within 7 days of discharge.

Overall, there was high adherence to pathway care processes in our study. However, even with the presence of a clinical pathway, variation in care for bronchiolitis remains.[11] Variability in adherence was more prevalent in the ED compared with the inpatient setting, which may be due to more diagnostic uncertainty and the shorter period of time in which ED physicians have to determine the diagnosis, treatment response, and caregiver ability to provide necessary care. We did not identify significant differences in cost or LOS by inpatient adherence score tertiles. We hypothesize that this may be due

to the bronchiolitis clinical pathway being established 6 years before the study start date, resulting in a lack of variation in performance and overall high adherence to the pathway care processes assessed. Alternatively, the process measures we targeted may lack discriminant validity for the quality outcomes examined (ie, LOS and costs). Future multicenter prospective studies may demonstrate increased variation in adherence to the targeted care processes and thus provide improved statistical power to examine associations between adherence levels and outcomes. If the targeted process measures represent those where adherence is uniformly high across institutions, exploration of alternative care processes that better predict outcomes would be warranted.

Although the majority of variability was observed in adherence to the ED indicators, shorter inpatient LOS and lower total costs were not explained by ED adherence alone. Thus, there may be an interaction between adherence to care processes across settings. For example, subjects with high ED adherence may be those presenting with a clearer bronchiolitis diagnosis from the beginning, which carries through their hospitalization. The majority of previous studies looking at implementation of clinical pathways and CPGs have focused on the inpatient setting.[4,11,13,14,17,26] In situations where there is little room to improve on inpatient adherence, focusing on adherence to evidence-based care processes in the ED setting may have implications for better use and cost outcomes in both settings. Although the benefits of cost and time savings with higher adherence to ED pathway care processes are more modest per case than those for admitted patients, because the volume of ED bronchiolitis cases is large, an important opportunity remains for improved quality and health care use in this setting.[2,27]

Previous studies have focused on decreasing resource use in the management of bronchiolitis, but few have demonstrated differences in cost as a result.[3,13,14,27–30] We demonstrated that after adjusting for LOS, adherence to evidence-based care processes within the clinical pathway was associated with lower ED and inpatient hospitalization costs by 14% and 29%, respectively. Specifically, we found that adherence to pathway care processes was associated with lower respiratory therapy, radiographic, and laboratory testing costs.

Studies examining the success of clinical pathway or CPG implementation have generally focused on process measures, including activation of order sets and the use of medical treatments and therapies.[11,12,14,28,30] Our study demonstrates the importance of using more refined measures of adherence to fully understand whether clinical pathways and CPGs are being implemented as intended and that doing so across the ED and inpatient settings can lead to measurable differences in health care use and cost. Because variation in care for bronchiolitis still exists across hospitals nationally, institutions should consider routinely assessing adherence to evidence-based quality indicators. Such assessments would facilitate targeting quality improvement efforts toward care processes with the most variability and the highest impact on health care use.[26] Implementation of tools like PRIMES that allow us to examine the association between the quality of care processes and health care use and costs gives us a mechanism to assess the value of the care we are providing.

Limitations

We conducted a single-center study based specifically on the SCH bronchiolitis clinical pathway, which limits generalizability across institutions. We also collected data retrospectively using medical record review, which only accounted for documented care processes. Therefore, we are unable to make any causal inferences between pathway adherence and health care use outcomes.

Patient severity of illness may have influenced adherence to the clinical pathway. We attempted to account for diagnostic uncertainty and illness severity by using an exclusive discharge diagnosis of bronchiolitis and excluding patients with relevant comorbidities. We also adjusted for triage acuity using a validated marker of ED illness severity; however, this may not be a sensitive marker of inpatient illness severity.[31] Because this was a retrospective study, we may not have fully eliminated residual confounding based on diagnostic uncertainty and illness severity.

We were unable to control for variables that may have influenced timely discharge, such as parental anxiety, transportation issues, or access to posthospitalization follow-up care. Furthermore, due to the lack of variation in performance and high overall adherence to inpatient care processes, we were unable to adequately assess relationships between inpatient adherence and health care use and costs. Future studies at institutions with greater variation in adherence to inpatient care processes are needed to better understand these relationships.

We were only able to account for some of the difference in cost

observed between the low and high adherence score tertiles, specifically, lower respiratory therapy, radiographic, and laboratory testing costs. Our relatively small sample size may have limited our ability to detect differences in other costs categories due to the high fixed direct costs associated with bed occupancy.[32]

CONCLUSIONS

This study illustrates the importance of clinician adherence to specific pathway care processes, which is variable despite the presence of a robust clinical pathway. Our study demonstrates that high adherence to evidence-based recommendations within a clinical pathway across the entire continuum of care, from the ED to the inpatient setting, is associated with lower costs and shorter LOS. By improving adherence to evidence-based recommendations within a clinical pathway, we may be able to provide higher-value care by optimizing the quality of bronchiolitis care at lower costs and with shorter LOS.

ABBREVIATIONS

CI: confidence interval
CPG: clinical practice guidelines
ED: emergency department
ICD-9: *International Classification of Diseases, Ninth Edition, Clinical Modification*
LOS: length of stay
SCH: Seattle Children's Hospital
PMCA: Pediatric Medical Complexity Algorithm
PRIMES: Pediatric Respiratory Illness Measurement System

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