Standardized Clinical Pathways for Hospitalized Children and Outcomes

K. Casey Lion, MD, MPH,^{a,b} Davene R. Wright, PhD,^{a,b} Suzanne Spencer, MBA, MHA,^c Chuan Zhou, PhD,^{a,b} Mark Del Beccaro, MD,^{a,d} Rita Mangione-Smith, MD, MPH^{a,b}

abstract

BACKGROUND AND OBJECTIVE: Clinical pathways standardize care for common health conditions. We sought to assess whether institution-wide implementation of multiple standardized pathways was associated with changes in utilization and physical functioning after discharge among pediatric inpatients.

METHODS: Interrupted time series analysis of admissions to a tertiary care children's hospital from December 1, 2009 through March 30, 2014. On the basis of diagnosis codes, included admissions were eligible for 1 of 15 clinical pathways implemented during the study period; admissions from both before and after implementation were included. Postdischarge physical functioning improvement was assessed with the Pediatric Quality of Life Inventory 4.0 Generic Core or Infant Scales. Average hospitalization costs, length of stay, readmissions, and physical functioning improvement scores were calculated by month relative to pathway implementation. Segmented linear regression was used to evaluate differences in intercept and trend over time before and after pathway implementation.

RESULTS: There were 3808 and 2902 admissions in the pre- and postpathway groups, respectively. Compared with prepathway care, postpathway care was associated with a significant halt in rising costs (prepathway vs postpathway slope difference $-\$155$ per month [95% confidence interval $-\$246$ to $-\$64$]; $P = .001$) and significantly decreased length of stay (prepathway vs post-pathway slope difference -0.03 days per month [95% confidence interval -0.05 to -0.02]; $P = .02$), without negatively affecting patient physical functioning improvement or readmissions.

CONCLUSIONS: Implementation of multiple evidence-based, standardized clinical pathways was associated with decreased resource utilization without negatively affecting patient physical functioning improvement. This approach could be widely implemented to improve the value of care provided.

^aDepartment of Pediatrics, University of Washington, Seattle, Washington; ^bCenter for Child Health, Behavior, and Development, Seattle Children's Research Institute, Seattle, Washington; and ^cDepartment of Clinical Effectiveness, ^dSeattle Children's Hospital, Seattle, Washington

Dr Lion participated in study conceptualization and design and drafted the initial manuscript; Drs Wright and Zhou participated in study conceptualization and design, performed part of the data analysis, and critically reviewed and revised the manuscript; Ms Spencer was instrumental in data acquisition, performed part of the data analysis, and critically reviewed and revised the manuscript; Dr Del Beccaro participated in study conceptualization and critically reviewed and revised the manuscript; Dr Mangione-Smith oversaw all aspects of the study, participated in study conceptualization and design, and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

DOI: 10.1542/peds.2015-1202

Accepted for publication Dec 22, 2015

WHAT'S KNOWN ON THIS SUBJECT: Standardized clinical pathways have been shown to improve some aspects of care delivery for particular conditions. It is unknown whether standardized pathway use across multiple conditions can improve the value of care provided.

WHAT THIS STUDY ADDS: Implementation of 15 standardized pathways across multiple general pediatric conditions was associated with increased value of care, through decreased length of stay and a halt in rising costs without negatively affecting patient physical functioning improvement or readmissions.

To cite: Lion KC, Wright DR, Spencer S, et al. Standardized Clinical Pathways for Hospitalized Children and Outcomes. *Pediatrics*. 2016;137(4):e20151202

Clinical pathways, which standardize care for common conditions, are increasingly used as hospitals strive to provide higher value care by improving quality while containing costs.^{1–3} Pathway development aims to accelerate the implementation of evidence into clinical practice, thus decreasing unwarranted variability in care, which is known to lead to worse outcomes and higher costs.^{4,5}

Current evidence supports the effectiveness of some individual pathways to decrease utilization and improve outcomes among specific patient populations.⁴ However, the impact of studied pathways varies by location and condition, making it difficult to know how much of the effect is due to pathway specifics and how much is due to standardization and reduced variability.² Additionally, the evidence base for pathway use in pediatric populations is limited.^{3,6}

In 2010, Seattle Children's Hospital (SCH) undertook a hospital-wide initiative to develop and implement clinical standard work (CSW) pathways for a range of pediatric conditions. The CSW approach applied a standard process to develop and implement evidence-based clinical pathways, aiming to improve outcomes while reducing unnecessary utilization. The objective of this study was to assess whether implementation of the CSW system was associated with hospitalization costs, length of stay (LOS), degree of physical functioning improvement after hospital discharge, and readmissions.

METHODS

CSW Development and Implementation

CSW pathway development is guided by 3 principles: (1) treatment should be evidence-based where possible and otherwise consensus-based, (2) recommendations should be

TABLE 1 Pathway Order-Set Use in the First 3 Months After Pathway Implementation and in the Last 3 Months of Data Included in Study

Pathway	Order Set Use, Months 1–3, %	Order Set Use in Most Recent 3 Months of Study, %	Number of Postpathway Study Months
Urinary tract infection	20	20	45
Diabetes DKA	100	96	35
Fractures: femur	94	82	31
Fractures: supracondylar	89	97	31
Spine	21	62	28
Croup	38	68	27
Neonatal jaundice	100	100	21
Depressive disorders	90	95	21
Pyloric stenosis	100	100	19
Pneumonia	42	67	18
Tonsillectomy and adenoidectomy	62	88	18
Disruptive behavior disorders	87	88	18
Diabetes non-DKA	83	89	10
Neonatal fever	41	57	8
Cellulitis and abscess	42	27	7

DKA, diabetic ketoacidosis.

hardwired into electronic order sets to encourage adherence, and (3) outcome measures must be owned and tracked by someone who is responsible for pathway continuous improvement.

Development of each CSW pathway begins with a literature review. Key stakeholders, clinicians and experienced CSW consultants prepare a pathway draft based on the literature, which is then reviewed by other clinical experts. Pathways include an order set in the electronic medical record, providing suggested orders, embedded decision support, and references. With launch of each new pathway, relevant clinicians must complete an online training module and required quiz. Pathway-related information is posted near clinician computers, and materials are integrated into provider and nurse workflow to simplify pathway use. During implementation, audit and feedback as well as targeted education by clinical champions are used to increase use. Pathway order-set use, selected clinical metrics, and safety events are monitored and reviewed at least quarterly, and revisions are made as needed. Order-set use varies by condition, from 100% order-set activation

for eligible patients over time (eg, neonatal jaundice), to lower levels of use, especially immediately after implementation (eg, croup, 38% use in the initial 3 months and 68% use in the most recent 3 months; Table 1). The degree to which patients receive pathway-recommended care when the order set is not activated is unknown, although metrics related to specific recommendations indicate that pathway-recommended care does occur without order-set use. For example, whereas 21% of patients eligible for the urinary tract infection pathway had order-set activation, 48% received pathway-recommended discharge antibiotics.

Between 2010 and 2014, 15 new pathways related to general pediatric conditions were developed and implemented as part of a larger initiative addressing general pediatric and subspecialty care. Seventeen million dollars were budgeted over 5 years for the initiative (mostly for salary support), including ~1000 person-hours dedicated to developing and implementing each pathway and 1000 person-hours for pathway maintenance and improvement. Full documentation of each pathway is available at <http://www.sch.wa.gov>.

seattlechildrens.org/healthcare-professionals/gateway/pathways. Pathways are monitored after implementation, with periodic review and alterations as needed. For example, for the croup pathway, LOS, order-set usage, and percent of patients receiving dexamethasone are tracked quarterly. This review-and-alteration cycle is a central tenet of continuous performance improvement and is considered part of the intervention. Given the large number of pathways, we did not study the postimplementation changes separately but consider them an integral part of the postpathway intervention period.

Study Design and Population

This was a retrospective cohort study examining admissions eligible for 1 of 15 general pediatric pathways between December 1, 2009, and March 30, 2014. We did not include admissions eligible for pathways that predated this time period because no preintervention data would be available, nor did we include admissions eligible for pathways for children with complex, uncommon subspecialty conditions, such as inflammatory bowel disease. All included pathways were implemented during the study time period, so the study included pathway-eligible admissions, both before and after implementation, for each of the 15 pathway conditions. Pathway eligibility was based on pathway-specific inclusion and exclusion criteria, including diagnosis, age, and comorbid conditions based on *International Classification of Disease Ninth Revision, Clinical Modification* (ICD-9) codes. To identify the “pathway eligible” cohort during the prepathway period, we used the same eligibility criteria that would have qualified for care on the pathway had the pathway been active. We used the Pediatric Medical Complexity Algorithm (PMCA)⁷

to classify children as having no chronic conditions, noncomplex chronic conditions, or complex chronic conditions, on the basis of retrospective ICD-9 codes, beginning with the date of admission and including up to a 3-year retrospective lookback period. Because included pathways were all intended for general pediatric populations, we excluded admissions involving patients with complex chronic conditions. All other pathway-eligible admissions were included in the analysis, regardless of whether the relevant order set was activated, as pathways were meant to influence clinical care even when the order set was not used. For patients with multiple admissions within the study time frame, only the first admission per 30-day period was eligible.

Outcome Measures

Patient-level outcome measures included total hospital costs, LOS in days, unplanned 30-day hospital readmissions, and physical functioning improvement after hospitalization.

Costs of Hospitalization and LOS

Total charges per hospital stay, excluding physician professional fees, and LOS data were obtained from hospital administrative data. Charges were converted to costs using the hospital-specific cost-to-charge ratio, then inflation-adjusted to 2013 US dollars using the medical care component of the Consumer Price Index.^{8,9} The same hospital cost-to-charge ratio was used for both study time periods. Given the skewed distributions, the highest 1% of costs and LOS were truncated at the 99th percentile.

Physical Functioning Improvement

Improvement in physical functioning after hospital discharge was assessed using the Pediatric Quality of Life Inventory 4.0 Generic Core or Infant Scales (PedsQL) physical functioning subscale.^{10–12} We

only used the physical functioning subscale because we hypothesized that changes to clinical care would most likely influence physical (rather than psychosocial) functioning, and previous research has found the physical component to be most responsive to posthospital recovery.¹³ At SCH, the PedsQL is administered to consenting parents (patients aged 1 month–18 years) and assenting patients within 72 hours of admission and again 2 to 8 weeks after discharge. Ineligible families included those who had completed the survey within the past 2 months, had a child who was immunocompromised, or who was admitted for suspected child abuse. In 2011–2013, 65% of eligible families completed the admission survey, and 58% completed the follow-up. For analyses, parent-proxy report was used for all patients aged <13 years. For teens, self-report was used when available; otherwise, parent proxy report was used. Scores were converted to a 0 to 100 scale, and improvement scores were calculated as the difference between follow-up and admission scores. On the basis of previous research, the minimal clinically important difference on the 0 to 100 scale is 4.5.¹⁰

Unplanned Readmissions

Unplanned 30-day readmissions were assessed from hospital administrative data. Readmissions were classified as unplanned using the methods developed by Berry et al, based on the ICD-9 procedure codes determined likely to represent a readmission related to a planned procedure.¹⁴ Readmissions were all cause and included both inpatient and observation stays.

Statistical Analysis

To compare all pathways we considered time on a relative scale, with the month and year of pathway implementation as the 0-point (t_0) for each of the 15 included

pathways. We then considered all 15 pathways simultaneously, with the time of implementation lined up across pathways, and each pathway contributing a variable number of pre- and postimplementation months based on when it was rolled out within the study period. For example, the pathway for diabetic ketoacidosis was implemented in April 2011, contributing 16 months preimplementation (months t_{-16} through t_{-1}) and 35 months postimplementation (months t_0 through t_{34}). We truncated groups at 36 months pre- and postpathway implementation, creating a “ ≥ 36 months” category given fewer observations at the tails.

After aligning all pathways around month of implementation, time series data were generated by calculating the mean value for each outcome at each time point (ie, by month relative to implementation).^{15,16} Thus, the data point for hospital cost in month +3 reflects average cost of hospitalization for study admissions from all 15 pathways in the third month after pathway implementation. These time series data for each outcome were then used in segmented regression models, which fit a separate regression line to each time period (pre- and postpathway implementation).¹⁷ This method produced separate intercepts and slopes for the pre- and postpathway periods, each of which was accompanied by a *P* value testing whether it was different from 0. We also tested whether the pre- and postpathway period intercepts and slopes were statistically different from one another, using the *lincom* command in Stata. This approach allows for detection of differences in both trends over time (ie, the slope) and intercepts.

To explore the relative contribution of each pathway to the overall findings, we stratified the segmented regression for each outcome by

individual pathway. To determine whether changes in patient medical complexity or frequency of observation stays over time influenced our findings, we used segmented regression to evaluate changes in the proportion of study admissions per month with no chronic conditions (vs noncomplex chronic conditions) and, in a separate model, with an inpatient stay (vs an observation stay).

This study was approved by the Seattle Children’s Institutional Review Board.

RESULTS

Inclusion criteria were met for 3808 prepathway admissions and 2902 postpathway admissions. Individual pathways contributed 7 to 44 months of prepathway data and 7 to 45 months of postpathway data (Fig 1). Patients with pathway eligible admissions were similar in both time periods (Table 2).

During the prepathway period, hospital costs per admission were steadily rising at a rate of \$126 per month (95% confidence interval [CI] \$60 to \$191; Fig 2A). Pathway implementation was associated with a statistically significant halt in the rate of rise in costs (postpathway slope -29 per month [95% CI $-\$100$ to $\$34$], *P* value for slope difference between time periods = .001; $R^2 = 0.98$). Compared with the costs per patient predicted by the prepathway slope trajectory, the actual postpathway costs were \$155 lower per month (95% CI $-\$246$ to $-\$64$; *P* = .001).

Using segmented regression, we found that prepathway LOS was stable over time, with a mean of 3.3 days and no significant slope to the regression line (Fig 2B). Pathway implementation was associated with a steady decrease in LOS, at a rate of -0.03 days (or 43 minutes) per admission per month (95% CI -0.05

to -0.02 ; *P* value for slope difference between time periods = .02; $R^2 = 0.97$), which amounts to 8.6 hours over the course of a year.

There were no significant differences by time period in 30-day readmissions, either in trend over time or intercepts based on segmented regression (Fig 3A).

During the prepathway period, there was no significant trend in physical functioning improvement scores (Fig 3B). After pathway implementation, there was a significant increasing trend over time, at a rate of 0.5 points per month (95% CI 0.1 to 0.8), or 6 points per year, which exceeds the minimal clinically important difference of 4.5. However, the difference between the pre- and postpathway period slopes was not statistically significant (*P* = .22; model $R^2 = 0.86$).

In analyses exploring the relative contribution of each pathway, we found few statistically significant differences from the pre- to postpathway periods, likely because of smaller samples (Supplemental Table 3). The individual results for cost generally mirrored the overall results: 8 pathways had significantly increasing costs prepathway, of which 2 demonstrated a statistically significant decrease in slope between pre- and postpathway period, whereas 5 showed a decrease that approached significance (*P* = .05 to -0.1). Individual results for LOS and physical functioning improvement were more variable, with few significant time trends for either period or the difference between periods. There were no significant readmission findings for any pathway.

We found a small but significant increase in the percent of study patients with no chronic conditions (45.4% prepathway, 50.1% postpathway, *P* = .01), compared with noncomplex chronic conditions, but no significant time trends. In contrast,

we found a significantly increasing trend over time in the percent of study patients with an inpatient compared with observation stay (prepathway slope -0.7% per month [95% CI -1.1 to -0.3], postpathway slope $+0.9\%$ per month [95% CI 0.5 to 1.2]; pre- to postpathway slope difference $+1.5\%$ [95% CI 1.0 to 2.1], $P < .001$).

DISCUSSION

In this interrupted time series analysis of general pediatric inpatients, we found that implementation of standardized, pathway-based care was associated with a halt in rising hospital costs, decreased LOS, and stable physical functioning improvement scores over time, without detriment to readmission rates. This study's

TABLE 2 Characteristics of Patient Admissions in the Prepathway and Postpathway Implementation Time Periods

	Prepathway (n = 3808)	Postpathway (n = 2902)
Male gender, n (%)	2080 (54.6)	1482 (51.1)
Age, y, mean (SD)	7.1 (5.9)	6.8 (5.9)
PMCA, n (%)		
Nonchronic	1728 (45.4)	1456 (50.1)
Noncomplex chronic	2070 (54.6)	1446 (49.9)
Complex chronic	excluded	excluded
Insurance type, n (%)		
Commercial	2290 (60.1)	1735 (59.8)
Public	1518 (39.9)	1167 (40.2)
Race/ethnicity, n (%)		
Non-Hispanic white	2235 (58.7)	1612 (55.3)
Hispanic	492 (12.9)	423 (14.5)
Black/African American	212 (5.6)	185 (6.4)
Asian or Pacific Islander	232 (6.1)	229 (7.9)
Other	378 (9.9)	338 (11.6)
Refused/unknown	259 (6.8)	127 (4.4)
Preferred language for care, n (%)		
English	3332 (87.5)	2529 (87.1)
Spanish	264 (6.9)	216 (7.4)
Other	212 (5.6)	157 (5.4)

PMCA, Pediatric Medical Complexity Algorithm, indicating degree of medical complexity based on up to 3 years' worth of ICD-9 codes.

FIGURE 1

Numbers of admissions and study months before and after pathway implementation, by pathway. Date of pathway implementation is indicated next to the pathway name. A, Numbers of admissions meeting pathway criteria, before and after each pathway was implemented. B, Number of months included in study by pathway, before and after implementation. *Inclusion criteria for this pathway depends on clinical documentation of fever, which was not available in the electronic medical record until February 2012, which is why there are fewer months of data for this pathway than others. DKA, diabetic ketoacidosis.

FIGURE 2

Interrupted time series analysis results for costs of hospitalization and LOS, before and after implementation of pathways. Pathway implementation is denoted by the dashed center line. A, Monthly average hospital costs per admission in 2013 US dollars. B, Monthly average LOS in days. All estimates are followed by 95% CIs in parentheses. ^aIntercept represents the y-intercept for each time period–specific regression line. ^bSlope is the slope for each time period–specific regression line, which indicates the change in outcome by month over the study period. For example, the prepathway cost regression line has a slope of +126, meaning average per-patient costs were increasing by \$126 per month during the prepathway period. ^cDifference between pre- and postpathway period slopes is the calculated difference in time period–specific slopes, indicating the change from the trajectory established during the prepathway period to the trajectory observed during the postpathway period. P value indicates whether the 2 slopes are statistically different from one another. ^dDifference between pre- and postpathway period intercepts is the calculated difference in time period–specific intercepts, indicated the mean value for the outcome at the beginning of the time period. When no significant slope exists during the time period, the intercept is equal to the mean value for the time period.

primary strength was using a relative time scale for the interrupted time series so that trends over time could be evaluated while distributing the impact of secular trends within each pathway over various study months. Thus the results are unlikely to be attributable to secular trends.

Implementation of clinical pathways has previously been associated with varying degrees of improvement in clinical complications, physician documentation, LOS, and/or hospital costs, depending on study.^{4,18–20} These previous studies, however, evaluated a single pathway at a time, generating evidence for the impact of a particular pathway within a particular context.^{2,4,20–32} The inclusion of patients who received care from a diverse range of pathways was another strength of this study because it allowed

for evaluation of the standardized pathway development and implementation process itself, rather than the elements of a particular condition-specific pathway. By evaluating clinical pathways in aggregate, our findings support an association between evidence-based standardization and the outcomes studied. These findings suggest that a process of pathway development, applied systematically across a broad range of diagnoses, can increase the value of health care provided by improving or maintaining clinical outcomes while decreasing LOS and containing costs. Although including a diverse set of pathways in the analysis precluded explicit examination of process measures, previous studies documenting decreased variability in care with standardized pathway use suggest increased adherence

to evidence-based care as a potential mechanism to explain our findings.^{33–35}

The current US health care climate of high and increasing expenditures with poor health outcomes relative to most other developed nations requires interventions that can address the triple aim of simultaneously improving individual experiences of care, improving the health of populations, and reducing per capita health care cost.³⁶ To achieve these goals requires understanding the impact of health care interventions on patient recovery, from the perspective of patients and families.³⁷ The inclusion of a patient-centered outcome, physical functioning improvement postdischarge, ensured that this study addressed not only costs of care but important health outcomes,

FIGURE 3

Interrupted time series analysis results for readmissions and physical functioning improvement scores, before and after implementation of pathways. Pathway implementation is denoted by the dashed center line. A, Monthly average unplanned hospital readmissions within 30 days of index admission. B, Monthly average physical functioning improvement scores, calculated as score at follow-up minus score at hospital admission. All estimates are followed by 95% CIs in parentheses. ^aIntercept represents the y-intercept for each time period–specific regression line. ^bSlope is the slope for each time period–specific regression line, which indicates the change in outcome by month over the study period. For example, the prepathway cost regression line has a slope of +126, meaning average per-patient costs were increasing by \$126 per month during the prepathway period. ^cDifference between pre- and postpathway period slopes is the calculated difference in time period–specific slopes, indicating the change from the trajectory established during the prepathway period to the trajectory observed during the postpathway period. The P value indicates whether the 2 slopes are statistically different from one another. ^dDifference between pre- and postpathway period intercepts is the calculated difference in time period–specific intercepts, indicated the mean value for the outcome at the beginning of the time period. When no significant slope exists during the time period, the intercept is equal to the mean value for the time period.

thus allowing us to assess the value of pathway implementation.

In this era of health care reform, an intervention such as that studied here, which was associated with maintained or improved patient-reported outcomes while decreasing or containing health care costs and LOS, could be considered by other hospitals and provider networks looking to increase the value of care provided.

Although sensitivity analyses demonstrated that the proportion of children with no chronic conditions increased in the postpathway period, which could have contributed to lower costs and shorter LOS, there was no significant trend in this finding over time. In addition, we found a simultaneous increase in inpatient versus observation hospitalizations, which would be

expected to exert the opposite effect on our outcomes (ie, increased LOS and higher costs). Therefore, our results are unlikely to merely reflect a change in study population.

This study has several limitations. We were unable to identify a reasonable parallel control group because the majority of patients with relatively common general pediatric diagnoses were either eligible for 1 of the 15 study pathways or for a pathway that predated the study period, such as asthma. Although the relative time scale helped to distribute secular trends within each pathway over both the pre- and postimplementation study periods, there may still be external factors influencing our results. However, there were no changes to pay-for-performance initiatives related to our outcomes during the study time period or other identifiable factors

likely to influence our results. We were unable to determine the degree of pathway adherence, so we likely included patients who did not receive pathway care; however, such cases would bias our results toward the null. Although combining diverse pathways allowed evaluation of standardization in general, it limited our ability to measure the impact on disease-specific clinical outcomes or track process measures that would indicate whether standardization resulted in decreased variability in care. We were also unable to identify which particular steps within individual pathways had the greatest association with outcomes. However, multifaceted interventions like pathway implementation are more likely to be effective than those with only a single component,³⁸ so isolating the impact of individual steps within pathways may not

be useful. In addition, combining pathways together may have obscured effects that are specific to an individual pathway. However, the most prevalent pathway (depressive disorders) contributed <15% of admissions to both the pre- and postimplementation periods, making it unlikely to have disproportionately influenced the results. While some of the individual pathways were more impactful than others, the sample sizes within each pathway were generally too small to draw definitive conclusions about how much each pathway contributed to the overall findings.

CONCLUSIONS

Implementation of a large-scale system for developing and applying standardized care pathways across

several health conditions was associated with decreased LOS and costs of care, while maintaining levels of improvement in patient postdischarge physical functioning. These results suggest an approach that could be implemented broadly. A system of clinical pathways, integrating the best available evidence using a rigorous process, holds promise for meeting the challenges facing our health care system today: to enhance the value of care by decreasing costs and resource utilization while maintaining or improving patient-centered outcomes.

ACKNOWLEDGMENTS

The authors thank Kathy Mullin, the entire Clinical Effectiveness team,

and the countless individuals who have participated in developing, implementing, and monitoring the clinical standard work pathways and guidelines.

ABBREVIATIONS

CI: confidence interval
 CSW: clinical standard work
 ICD-9: *International Classification of Disease Ninth Revision*
 Clinical Modification:
 LOS: length of stay
 PEDSQL: Pediatric Quality of Life Inventory 4.0 Generic Core or Infant Scales
 SCH: Seattle Children's Hospital

Address correspondence to K. Casey Lion, MD, MPH, University of Washington, and Center for Child Health, Behavior and Development, Seattle Children's Research Institute; M/S CW8-6, PO Box 5371, Seattle, WA 98145-5005. E-mail: casey.lion@seattlechildrens.org

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2016 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: This work was funded by the Department of Clinical Effectiveness, through hospital operations at Seattle Children's Hospital.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

REFERENCES

- Kimberly J, de Pourourville G, d'Aunno T. *The Globalization of Managerial Innovation in Health Care*. Cambridge, UK: Cambridge University Press; 2009
- Saint S, Hofer TP, Rose JS, Kaufman SR, McMahon LF Jr. Use of critical pathways to improve efficiency: a cautionary tale. *Am J Manag Care*. 2003;9(11):758–765
- Rotter T, Kinsman L, James E, Machotta A, Steyerberg EW. The quality of the evidence base for clinical pathway effectiveness: room for improvement in the design of evaluation trials. *BMC Med Res Methodol*. 2012;12:80
- Rotter T, Kinsman L, James E, et al. Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. *Cochrane Database Syst Rev*. 2010;(3):CD006632
- Kinsman L, Rotter T, James E, Snow P, Willis J. What is a clinical pathway? Development of a definition to inform the debate. *BMC Med*. 2010;8:31
- Melnik BM, Grossman DC, Chou R, et al; US Preventive Services Task Force. USPSTF perspective on evidence-based preventive recommendations for children. *Pediatrics*. 2012;130(2). Available at: www.pediatrics.org/cgi/content/full/130/2/e399
- Simon TD, Cawthon ML, Stanford S, et al. Pediatric medical complexity algorithm: a new method to stratify children by medical complexity. *Pediatrics*. 2014;133(6). Available at: www.pediatrics.org/cgi/content/full/133/6/e1647
- Luce B, Manning W, Siegel J, Lipscomb J. Estimating costs in cost-effectiveness analysis. In: Gold M, Siegel J, Russell L, Weinstein M, eds. *Cost-Effectiveness in Health and Medicine*. New York, NY: Oxford University Press; 1996:176–213
- Bureau of Labor Statistics Consumer Price Index. Washington, DC: US Department of Labor; 2013. Available at: <http://data.bls.gov/timeseries/ CUUR0000SAM>. Accessed May 18, 2015
- Varni JW, Burwinkle TM, Seid M, Skarr D. The PedsQL 4.0 as a pediatric population health measure: feasibility, reliability, and validity. *Ambul Pediatr*. 2003;3(6):329–341
- Varni JW, Burwinkle TM, Seid M. The PedsQL as a pediatric patient-reported outcome: reliability and validity of the PedsQL Measurement Model in 25,000 children. *Expert Rev Pharmacoecon Outcomes Res*. 2005;5(6):705–719

12. Varni JW, Seid M, Kurtin PS. PedsQL 4.0: reliability and validity of the Pediatric Quality of Life Inventory version 4.0 generic core scales in healthy and patient populations. *Med Care*. 2001;39(8):800–812
13. Desai AD, Zhou C, Stanford S, Haaland W, Varni JW, Mangione-Smith RM. Validity and responsiveness of the pediatric quality of life inventory (PedsQL) 4.0 generic core scales in the pediatric inpatient setting. *JAMA Pediatr*. 2014;168(12):1114–1121
14. Berry JG, Toomey SL, Zaslavsky AM, et al. Pediatric readmission prevalence and variability across hospitals [published correction appears in JAMA. 2013;309(10):986]. *JAMA*. 2013;309(4):372–380
15. Penfold RB, Zhang F. Use of interrupted time series analysis in evaluating health care quality improvements. *Acad Pediatr*. 2013;13(suppl 6):S38–S44
16. Taljaard M, McKenzie JE, Ramsay CR, Grimshaw JM. The use of segmented regression in analysing interrupted time series studies: an example in pre-hospital ambulance care. *Implement Sci*. 2014;9:77
17. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. *J Clin Pharm Ther*. 2002;27(4):299–309
18. Hanna E, Schultz S, Doctor D, Vural E, Stern S, Suen J. Development and implementation of a clinical pathway for patients undergoing total laryngectomy: impact on cost and quality of care. *Arch Otolaryngol Head Neck Surg*. 1999;125(11):1247–1251
19. Jacavone JB, Daniels RD, Tyner I. CNS facilitation of a cardiac surgery clinical pathway program. *Clin Nurse Spec*. 1999;13(3):126–132
20. Mabrey JD, Toohey JS, Armstrong DA, Lavery L, Wammack LA. Clinical pathway management of total knee arthroplasty. *Clin Orthop Relat Res*. 1997; (345):125–133
21. Jones S. A clinical pathway for pediatric gastroenteritis. *Gastroenterol Nurs*. 2003;26(1):7–18
22. Kelly CS, Andersen CL, Pestian JP, et al. Improved outcomes for hospitalized asthmatic children using a clinical pathway. *Ann Allergy Asthma Immunol*. 2000;84(5):509–516
23. Kirk AT, Alder SC, King JD. Cue-based oral feeding clinical pathway results in earlier attainment of full oral feeding in premature infants. *J Perinatol*. 2007;27(9):572–578
24. Kwan-Gett TS, Lozano P, Mullin K, Marcuse EK. One-year experience with an inpatient asthma clinical pathway. *Arch Pediatr Adolesc Med*. 1997;151(7):684–689
25. Mitchell EA, Didsbury PB, Kruithof N, et al. A randomized controlled trial of an asthma clinical pathway for children in general practice. *Acta Paediatr*. 2005;94(2):226–233
26. Norton SP, Pusic MV, Taha F, Heathcote S, Carleton BC. Effect of a clinical pathway on the hospitalisation rates of children with asthma: a prospective study. *Arch Dis Child*. 2007;92(1):60–66
27. Roberts HC, Pickering RM, Onslow E, et al. The effectiveness of implementing a care pathway for femoral neck fracture in older people: a prospective controlled before and after study. *Age Ageing*. 2004;33(2):178–184
28. Rome ES, Moszczenski SA, Craighill M, et al. A clinical pathway for pelvic inflammatory disease for use on an inpatient service. *Clin Perform Qual Health Care*. 1995;3(4):185–196
29. Taylor KO, Goudie CM, Muller MJ. Evaluation of a pediatric scald burn clinical pathway. *J Burn Care Rehabil*. 2004;25(3):256–261
30. Wazeka A, Valacer DJ, Cooper M, Caplan DW, DiMaio M. Impact of a pediatric asthma clinical pathway on hospital cost and length of stay. *Pediatr Pulmonol*. 2001;32(3):211–216
31. Wilson SD, Dahl BB, Wells RD. An evidence-based clinical pathway for bronchiolitis safely reduces antibiotic overuse. *Am J Med Qual*. 2002;17(5):195–199
32. Wolff M, Schinasi DA, Lavelle J, Boorstein N, Zorc JJ. Management of neonates with hyperbilirubinemia: improving timeliness of care using a clinical pathway. *Pediatrics*. 2012;130(6). Available at: www.pediatrics.org/cgi/content/full/130/6/e1688
33. Newman RE, Hedican EB, Herigon JC, Williams DD, Williams AR, Newland JG. Impact of a guideline on management of children hospitalized with community-acquired pneumonia. *Pediatrics*. 2012;129(3). Available at: www.pediatrics.org/cgi/content/full/129/3/e597
34. Ambroggio L, Thomson J, Murtagh Kurowski E, et al. Quality improvement methods increase appropriate antibiotic prescribing for childhood pneumonia. *Pediatrics*. 2013;131(5). Available at: www.pediatrics.org/cgi/content/full/131/5/e1623
35. Murtagh Kurowski E, Shah SS, Thomson J, et al. Improvement methodology increases guideline recommended blood cultures in children with pneumonia. *Pediatrics*. 2015;135(4). Available at: www.pediatrics.org/cgi/content/full/135/4/e1052
36. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. *Health Aff (Millwood)*. 2008;27(3):759–769
37. Blackwell LS, Marciel KK, Quittner AL. Utilization of patient-reported outcomes as a step towards collaborative medicine. *Paediatr Respir Rev*. 2013;14(3):146–151
38. Hulscher ME, Wensing M, van Der Weijden T, Grol R. Interventions to implement prevention in primary care. *Cochrane Database Syst Rev*. 2001; (1):CD000362