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Rising utilization of inpatient pediatric asthma pathways

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ABSTRACT

Introduction: Clinical pathways are detailed care plans that operationalize evidence-based guidelines into an accessible format for health providers. Their goal is to link evidence to practice to optimize patient outcomes and delivery efficiency. It is unknown to what extent inpatient pediatric asthma pathways are being utilized nationally. **Objectives:** (1) Describe inpatient pediatric asthma pathway design and implementation across a large hospital network. (2) Compare characteristics of hospitals with and without pathways. **Methods:** We conducted a descriptive, cross-sectional, survey study of hospitals in the Pediatric Research in Inpatient Settings Network (75% children's hospitals, 25% community hospitals). Our survey determined if each hospital used a pathway and pathway characteristics (e.g. pathway elements, implementation methods). Hospitals with and without pathways were compared using Chi-square tests (categorical variables) and Student's t-tests (continuous variables). **Results:** Surveys were distributed to 3–5 potential participants from each hospital and 302 (74%) participants responded, representing 86% (106/123) of surveyed hospitals. From 2005–2015, the proportion of hospitals utilizing inpatient asthma pathways increased from 27% to 86%. We found variation in pathway elements, implementation strategies, electronic medical record integration, and compliance monitoring across hospitals. Hospitals with pathways had larger inpatient pediatric programs [mean 12.1 versus 6.1 full-time equivalents, $p = 0.04$] and were more commonly free-standing children's hospitals (52% versus 23%, $p = 0.05$). **Conclusions:** From 2005–2015, there was a dramatic rise in implementation of inpatient pediatric asthma pathways. We found variation in many aspects of pathway design and implementation. Future studies should determine optimal implementation strategies to better support hospital-level efforts in improving pediatric asthma care and outcomes.

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Introduction

Asthma, a leading cause of pediatric hospitalizations [1], costs nearly \$1 billion annually in the United States [2]. For decades, there have been efforts to improve asthma care by enhancing the use of evidence-based guidelines in clinical practice. However, significant barriers exist to providers integrating evidence-based guidelines into care [3–9]. Inconsistent adoption of evidence-based guidelines across providers contributes to variability in quality of care and outcomes for children hospitalized for asthma (transfer to intensive care unit, hospital readmission, length of stay [LOS], and cost) [10–15].

Clinical pathways are a promising tool for achieving universal adoption of evidence-based guidelines in practice and improving quality of care. Pathways are

detailed care plans that operationalize evidence-based guidelines into an accessible bedside format for health providers. Their goal is to link evidence to practice to optimize patient outcomes and delivery efficiency. Systematic reviews examining the effects of clinical pathways have shown significant reductions in hospital complications, LOS, and costs, as well as improvements in documentation [16]. Studies specifically focused on inpatient pediatric asthma pathways also demonstrate improvements in quality of care and reductions in LOS [17–19].

Hospitals interested in pathway implementation are faced with several challenges, including a lack of evidence-based guidance on implementation methods and a need for significant resources for pathway implementation [20–23]. Understanding the extent to which

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inpatient pediatric asthma pathways are being utilized nationally and how individual hospitals implement pathways can help inform and support ongoing pathway implementation efforts. Our objective was to describe inpatient pediatric pathway utilization across a large, diverse network of hospitals, including specific pathway characteristics and implementation strategies. These data will also provide the framework for future investigations to determine optimal pathway implementation strategies for improving care and outcomes for children hospitalized with asthma.

Methods

Study population

We performed a cross-sectional study by surveying key personnel from all hospitals within the Pediatric Research in Inpatient Settings (PRIS) Network. The PRIS network consists of 123 hospitals representing 45 states and 3 Canadian provinces. The network's mission is to improve the health of and health-care delivery to hospitalized children and their families [24].

We identified potential study participants by e-mailing the PRIS network site lead for each hospital. We provided a brief study description and asked for 3–5 experts from the hospital that were “closely involved in the care of children hospitalized with asthma and knowledgeable about evidence-based tools (e.g., clinical pathways) used in inpatient asthma care.” Survey respondents could include physicians, nurses, respiratory therapists, or administrators. We distributed the survey via e-mail to 3–5 experts identified at each hospital, as prior literature has indicated a need for multiple respondents per organization in organizational survey research [25]. We sent up to three follow-up inquiries at two-week intervals to non-respondents.

Survey development and content

The survey [Appendix 1] was developed through consensus by our research group of ten members with expertise in pediatric hospital medicine, pediatric asthma, health services research, survey methodology, implementation science, quality improvement, and qualitative methods. The survey first asked whether or not the hospital utilized a clinical pathway in the care of children hospitalized for asthma. We used an established definition of clinical pathways—in order to be classified as a pathway, the intervention had to satisfy four criteria: (1) it was a structured multidisciplinary plan of care, (2) it was used to translate guidelines or evidence into local structures, (3) it detailed the steps in a course of treatment or care in

a plan, pathway, algorithm, guideline, protocol or other “inventory of actions,” and (4) it aimed to standardize care for a specific population [26].

For those respondents who indicated that their hospitals had an inpatient pediatric asthma pathway, we asked what quarter and year the pathway was implemented, what types of health-care providers utilize the pathway, how the pathway is accessed electronically, what specific elements the pathway contained (e.g. medication guidance, checklist of items for discharge planning), and what strategies were used in implementing the pathway and monitoring compliance. Additionally, for all hospitals (with or without pathways) we asked about the use of other tools for inpatient pediatric asthma care (e.g. order sets), use of pathways in other clinical settings or for other conditions, and availability of outpatient asthma resources. The survey was pilot-tested by a convenience sample of six pediatric hospitalists and modified based on their feedback [27].

Survey aggregation

Survey responses and pathway documents (if provided by survey participants) were reviewed to verify that the pathway utilized by each hospital met the four criteria we used to define a pathway. All participant responses from each hospital were combined to facilitate hospital-level analyses. When we found discrepancies in the responses for date of pathway implementation, we contacted all survey respondents from that hospital via e-mail for clarification until consensus was reached among respondents from that hospital. For discrepancies in all other survey questions with dichotomous (yes/no) answers, if any respondent from the hospital indicated a “yes” response (e.g. utilization of a specific implementation strategy), we assumed that the characteristic was present, as this assumes that one respondent may have a specialized knowledge of the hospital pathway that another respondent may not have [28].

Hospital characteristics

Hospital characteristics were determined using the PRIS network survey, collected in 2014. Characteristics included hospital type (free-standing children's hospital, children's hospital within a hospital, community hospital), hospital location (urban, suburban, rural), teaching status, number of pediatric beds, annual pediatric admissions, and number of FTEs in the inpatient program/section. FTE was comprised of attending physicians, fellows, nurse practitioners, and/or physician assistants serving the pediatric inpatient program.

Analysis

Descriptive statistics were used to describe characteristics of the hospitals in the survey. Chi-square tests or Fisher exact tests, when indicated, were used to compare categorical characteristics between respondent and non-respondent hospitals and hospitals with and without inpatient pediatric asthma pathways. Student's *t*-tests were used to compare continuous characteristics across these groups [27]. All statistical analyses were performed using STATA, version 14 (College Station, TX, USA), and differences were considered statistically significant where $p \leq 0.05$.

For two survey questions that allowed free text responses, data were analyzed using a qualitative content analysis approach [29]. The first stage of coding involved reading through all collected data to gain an overall understanding of participant responses. Preliminary codes were not predetermined, instead, they were created inductively. Codes were then condensed into themes, and the themes most frequently recurring were presented.

Ethics approval

This study was considered exempt by the Institutional Review Board at the University of California, San Francisco.

Results

Hospital characteristics

Most PRIS Network hospitals are children's hospitals (43% free-standing children's hospitals, 32% children's hospitals within hospitals), (Table 1). Most hospitals are teaching hospitals (90%) in urban settings (68%). Approximately half of PRIS Network hospitals have <100 pediatric beds (51%), <5,000 annual pediatric admissions (53%), and <10 FTE (57%).

Survey results

Of the 408 participants we surveyed, 302 (74%) responded, with a mean of 2.7 responses (range 1–5) per hospital. The participants represented 106 (86%) PRIS network hospitals, and consisted of physicians (59%), respiratory therapists (13%), nurses (9%), nurse practitioners (3%), and hospital administrators (1%); forty-three (14%) participants did not indicate their clinical role. Table 1 describes comparisons between respondent and non-respondent hospitals, for which we were not able to collect any survey responses. Participating hospitals tended to be larger (more pediatric beds and yearly admissions), urban, teaching hospitals. Children's hospitals were more likely to have responded compared with community hospitals.

Table 1. Characteristics of All PRIS network hospitals and comparisons of respondents vs. non-respondents.

Characteristic	All Hospitals	Respondents	Non-Respondents	<i>p</i> -Value**
Total yearly admissions,* <i>n</i> (%)				
<5,000	52 (53%)	39 (47%)	13 (93%)	Ref
5,000–9,999	20 (21%)	20 (24%)	0 (0%)	0.01
≥10,000	25 (26%)	24 (29%)	1 (7%)	0.03
Total pediatric beds,* <i>n</i> (%)				
<50	38 (34%)	23 (24%)	15 (88%)	Ref
50–99	19 (17%)	18 (19%)	1 (6%)	0.01
100–199	19 (17%)	19 (20%)	0 (0%)	<0.001
200–299	21 (19%)	21 (22%)	0 (0%)	<0.001
≥300	15 (13%)	14 (15%)	1 (6%)	0.02
Total FTEs for pediatric inpatient program,* <i>n</i> (%)				
<10	63 (57%)	53 (57%)	10 (59%)	Ref
10–19	30 (27%)	26 (28%)	4 (24%)	1.0
20–29	7 (6%)	7 (8%)	0 (0%)	0.58
30–39	7 (6%)	7 (8%)	0 (0%)	0.58
≥40	3 (3%)	0 (0%)	3 (18%)	0.01
Hospital type, <i>n</i> (%)				
Free-standing Children's Hospital	50 (43%)	48 (48%)	2 (12%)	Ref
Children's Hospital within a Hospital	37 (32%)	35 (35%)	2 (12%)	1.0
Community Hospital with significant pediatric subspecialty services	6 (5%)	1 (1%)	5 (29%)	<0.001
Community Hospital with limited pediatric subspecialty services	23 (20%)	15 (15%)	8 (47%)	0.001
Teaching hospital, <i>n</i> (%)				
Yes	104 (90%)	93 (94%)	11 (65%)	<0.001
No	12 (10%)	6 (6%)	6 (35%)	
Location				
Urban	78 (68%)	73 (74%)	5 (31%)	Ref
Suburban	31 (27%)	22 (22%)	9 (56%)	0.03
Rural	6 (5%)	4 (4%)	2 (13%)	0.08

Notes. *A portion of hospitals did not provide a response to this question. **Compared using chi-square tests or Fisher exact tests, when indicated.

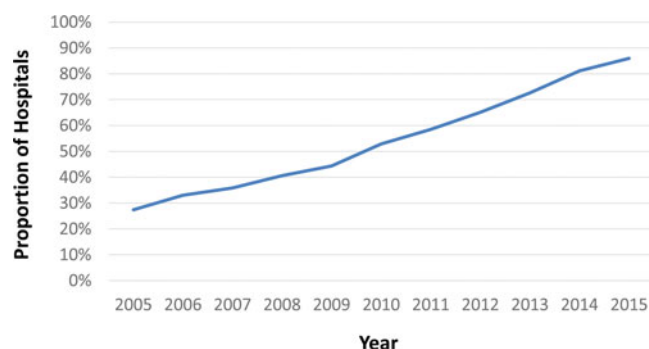


Figure 1. Cumulative proportion of hospitals utilizing pathways from 2005 to 2015.

The majority of hospitals, 91 (86%), utilized an inpatient pediatric asthma pathway. The cumulative proportion of hospitals utilizing pathways from 2005 to 2015 is illustrated in Figure 1. Twenty-nine hospitals (27%) had implemented a pathway prior to 2006, and an additional 62 additional hospitals implemented pathways from 2006 to 2015. A single hospital reported having a pathway in place prior to 2006, but discontinuing this pathway in 2010.

Pathway implementation

At hospitals that implemented pathways ($n = 91$), implementation commonly involved staff training and education (87 hospitals, 96%), and provider champions/leaders (85 hospitals, 93%). There was variation in the use of support from hospital administration/leadership (76 hospitals, 84%) and performance feedback (57 hospitals, 63%). Financial incentives were rarely used (4 hospitals, 4%).

Twelve hospitals (13%) had no EMR integration of the pathway and 12 (13%) hospitals had a link to the pathway within the EMR. Sixty-seven (74%) had integrated the pathway into the EMR with some form of decision-support for placing orders, and this ranged from order sets to detailed prompts for titrating therapy.

Participants were asked to provide free text responses regarding implementation: “Please use this space to add any additional factors you feel were important for dissemination and implementation of the inpatient asthma pathway/guideline.” The major themes from these responses paralleled the multiple-choice responses, but also highlighted important additional factors in implementation (Table 2). Some of these factors included expanding clinical duties of providers, addressing multiple health-care settings, updating the pathway, and promoting ease of pathway use.

Pathway utilization and monitoring

At hospitals that implemented pathways, participants reported that pathways were utilized by attending physicians at all 91 (100%) hospitals. Pathways were utilized by resident physicians at 83 (91%) hospitals, respiratory therapists at 82 (90%) hospitals, and nurses at 79 (87%) hospitals. Pathways were less frequently utilized by nurse practitioners (59 hospitals, 65%) and case managers (34 hospitals, 37%).

Sixty-eight (75%) hospitals actively tracked health provider compliance with the pathway, and 76 (84%) hospitals had engaged in efforts to promote pathway compliance. Table 3 describes participants’ free text responses to the question: “Please describe efforts to increase compliance.” These efforts included individual audit/feedback, reminders from other providers, continued pathway education efforts, electronic reminders and requirements, and financial incentives. Seventy-three (80%) hospitals reported that >75% of children hospitalized for asthma “received most or all of their asthma care based on the pathway.”

Pathway elements

The contents of the inpatient pediatric asthma pathways are illustrated in Figure 2. Elements with greater variability included checklists of items for discharge planning (73 hospitals, 80%), indications for subspecialist consultation (57 hospitals, 63%), and citations of primary literature (56 hospitals, 62%).

Other asthma tools and resources

Among all hospitals (those with and without pathways), most reported development of an inpatient pediatric asthma order set (98 hospitals, 92%). There was less utilization of pocket cards (40 hospitals, 38%) and utilization of pediatric asthma pathways in other settings, like outpatient clinics or emergency departments (83 hospitals, 78%).

There was also variability in the availability of other outpatient resources for children with asthma, such as asthma education programs (79 hospitals, 75%), smoking cessation programs (78 hospitals, 74%), case/care management (74 hospitals, 70%), and environmental assessments of home (51 hospitals, 48%).

Hospitals with and without pathways

Table 4 shows comparisons of hospitals with and without pediatric inpatient asthma pathways ($n = 106$). Hospitals

Table 2. Major themes and exemplary quotes regarding pathway implementation.

Major themes	Exemplary quote(s)
Crucial role of health provider training	"We did several walking rounds where we had staff walk through patient scenarios to score and treat patient" "We do an academic half day and other education in-services" "We do annual training and competencies for physicians, RNs, and RTs."
Importance of obtaining multidisciplinary stakeholder support and involvement	"Disciplines received didactic and simulated training, so the teams that work together would train together. Asthma Pathway meetings are multidisciplinary and allow for all members to share, learn and critique in an open and safe environment." "Creation of a multi-disciplinary Care Process Team dedicated to improving asthma care, which consists of physicians (ED, PHM, Pulmonary, ICU), nursing leadership, RTs, IT analysts to help build data warehouses for tracking, and quality improvement nursing/leaders to help drive changes."
Expanding clinical duties of providers	"The key to our success was using a respiratory therapy-driven asthma protocol that uses a score to guide therapy. Using this protocol allowed us to be more efficient, reliable and consistent with our asthma care." "Additional support of RT's for inpatient asthmatics on certain floors has helped nurses accommodate the time consuming (but vital aspects of assessment/treatment on the pathway). Also their expertise and comfort level with the pathway has helped with educating staff" "The fact that RTs and nurses drive the decision making on albuterol spacing once the initial severity level is assigned has also been an important part of its acceptance."
Collecting and sharing data on clinical outcomes	"When the pathway was created and launched ... length of stay was 4 days and the pathway cut it in half. This was an important characteristic of the pathway that allowed the clinical champions to make a business case for the pathway that was well received by hospital administration/executives." "Success of the pathway in making care better for patients makes our physicians much more likely to want to use the pathway." "We display dashboards monthly with asthma guideline metrics that are placed on the units. The near future plan is to have them uploaded and displayed on TV monitors within each unit."
Electronic integration of pathway	"Embedding it in the order set was the key" "We have a discharge order set in Epic that incorporates the Asthma HMP (Home Management Plan) and educational materials to print in the After Visit Summary. This is being updated to a newer and more user friendly HMP"
Crucial role of local pathway champions	"Prompt within EMR when asthma is admitting diagnosis." "Having a physician champion was key to the success of the asthma pathway." "Incorporation of residents into improvement team so that they could help spread the word was important."
Importance of addressing multiple health-care settings (e.g. emergency, inpatient, ICU, community)	"Our most important change with this and other pathways are to have them be patient-centric, not provider centric. So, we have input and education from ED to hospitalist to intensivist now."
Providing performance feedback to providers	"Feedback was given to attendings when we were out of compliance with the asthma core measure."
Updating the pathway	"We continually research the NAEPP guidelines and evidence-based practice to update the pathway for patients having acute asthma episodes and repeated admissions."
Promoting ease of pathway use	"Less work/time for physicians makes our physicians much more likely to want to use the pathway" "We added a quick tip sheet to the order set (embedded in Epic for easy access)"

Table 3. Major themes and exemplary quotes regarding efforts to increase compliance.

Major themes	Exemplary quote(s)
Individual audit/feedback	"Monthly monitoring of pathway/guideline use, including tracking individual attending physicians. Monthly meetings that include discussions on what can be done to increase overall compliance in using these pathways/guidelines."
Reminders from providers	"Pathway end-users (RNs, physicians, residents, RTs, etc) get quality metric data on a monthly basis." "Discharges reviewed and reminder provided if asthma action plan not used on discharge or by care coordinators or if admission action plan not ordered during admission." "For a while, we checked in with residents when the order sets weren't used" "Respiratory Therapist are encouraged to communicate with the doctors if their asthmatic patient is not placed on the pathway" "Our physician lead contacts us periodically to remind us about the recommendations based on the pathway."
Continued pathway education	"Continued education to medical team (attending physicians, nurse practitioners, resident physicians)" "Multiple communications in a variety of venues (newsletter, morning report, meetings with hospitalists, attending noon conferences and asthma-specific RT rounding with the inpatient teams)"
Electronic reminders and requirements	"It is required that we use this order set for all asthma admissions" "Improved prompts in EMR" "Make it a hard stop within the EMR for anybody with the diagnosis of asthma."
Provider Incentives	"Coffee cards for residents" "Linking individual MD salary bonus with achieving Joint Commission asthma core measures"

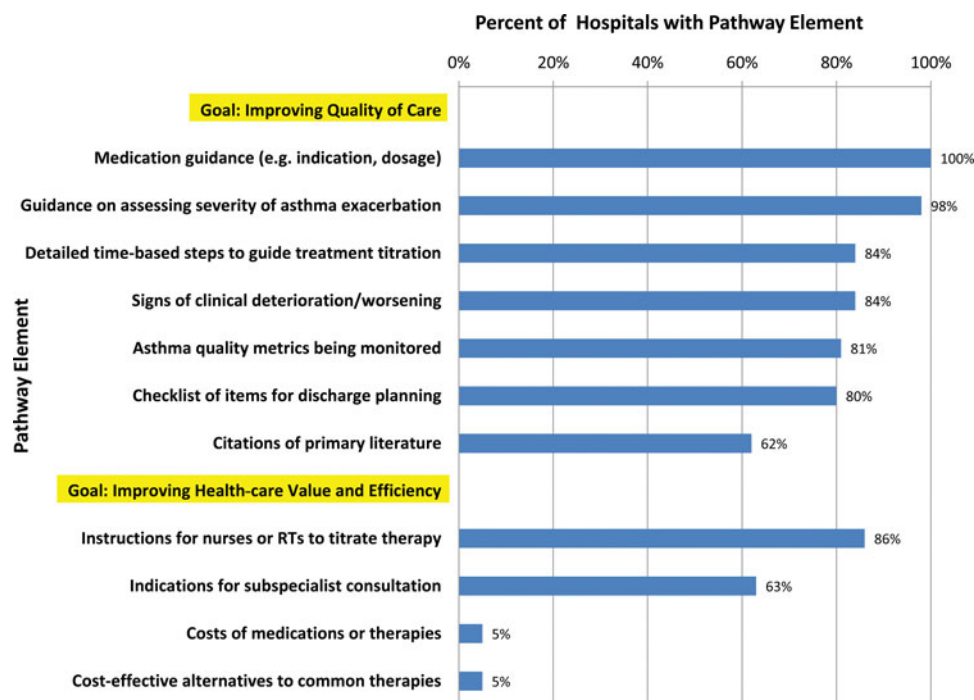


Figure 2. Elements included in inpatient pediatric asthma pathways.

with pathways had nearly double the mean FTEs for the pediatric inpatient program (12.1 versus 6.1, $p = 0.035$). Free-standing children's hospitals were also more likely to have implemented pathways compared to other hospital types, including children's hospitals within hospitals or community hospitals (94% versus 80%, $p = 0.049$). There

were no statistically significant differences in total pediatric beds or total annual pediatric admissions.

Discussion

This is the first study to our knowledge to describe the utilization and implementation of clinical pathways across a large, national sample of hospitals that care for children. Over the past decade, there has been a dramatic rise in hospitals investing resources into implementing inpatient pediatric asthma pathways. However, we found variation in multiple aspects of pathway design and implementation (e.g. pathway elements, implementation strategies, EMR integration, monitoring of pathway compliance), which may be due to a lack of evidence-based guidance on optimal implementation strategies. These variations in pathway implementation may also impact the efficacy of pathways in improving patient care and outcomes.

The rise in pathway implementation may have been driven by local desires to increase guideline adherence and improve quality of care. The rise may have also been driven by external factors such as the development of inpatient pediatric asthma performance metrics by the Joint Commission in 2007 [30], increasing pressures to publicly report hospital quality metrics [31], or changes in insurance reimbursement policies intended to incentivize providers to provide higher quality care at lower costs [32]. We found that hospitals with higher FTE and free-standing children's hospitals were more likely to implement pathways. These larger institutions may encounter

Table 4. Comparisons of hospitals with and without pathways.

Characteristics	Pathway ($n = 86$)	No pathway ($n = 14$)	p -Value*
Total pediatric beds, mean (95% CI)	170 (142–199)	130 (38–223)	0.32
Total yearly admissions, mean (95% CI)	7120 (5699–8540)	4535 (664–8406)	0.21
Total FTEs for pediatric inpatient program, mean (95% CI)	12.1 (10.1–14.2)	6.1 (3.7–8.5)	0.04
Hospital type, n (%)			0.05
Free-standing children's hospital	45 (52%)	3 (23%)	
Other**	41 (48%)	10 (77%)	
Teaching hospital, n (%)			
Yes	81 (94%)	12 (92%)	0.58
No	5 (6%)	1 (8%)	
Location, n (%)			
Urban	63 (73%)	10 (77%)	1.00
Suburban or rural	23 (27%)	3 (23%)	

Notes. *Calculated using Student's t -test, χ^2 test, or Fisher's exact test, as appropriate. **Includes children's hospitals within hospitals and community hospitals.

more pediatric asthma admissions and as a result, may have greater incentive to develop pathways. Larger hospitals may also have more capacity for investing time and resources into pathway development and implementation [19]. However, given that smaller community hospitals face many of the same external pressures to improve quality of care (e.g. public reporting of quality metrics) and care for over half of children hospitalized nationally [33], community hospital-focused strategies and supports for pathway implementation should be developed.

There are no other studies to our knowledge that describe regional or national patterns of pediatric clinical pathway utilization, but our findings parallel studies in the adult literature. In 2010, Neuman et al. found that 93% of acute care hospitals in Pennsylvania had developed and implemented at least one clinical pathway [34]. Bjurling-Sjöberg et al. examined the utilization of clinical pathways in Swedish intensive care units. Although they found only 20% of hospitals utilized pathways, they found variation in pathway development strategies, pathway content, implementation strategies, and EMR integration, in line with our findings [35]. Clinical pathway development and implementation has also varied across previous studies of inpatient pediatric asthma pathways [17,18,36–39], which is mirrored in our findings of variability in most aspects of pathway implementation. This variability may reflect the lack of evidence-based guidance on successful pathway implementation methods, and may contribute to variability in patient outcomes.

Most of the hospitals surveyed indicated “staff training and education” was part of the pathway implementation process; however, survey free text responses indicated substantial variability in the specific methods used. The methods included printed or electronic educational materials, didactic educational sessions, and/or simulation activities, among others. For hospitals implementing pathways, both printed materials and educational meetings can be successful [40]; however, interactive educational sessions that enhance participant activity and provide the opportunity to practice skills may change professional practice more effectively than didactic sessions [41]. Understanding setting-specific barriers to educational efforts is also crucial to successful implementation [42,43].

Another aspect of pathway implementation that was variable was the use of “performance feedback,” which can help overcome lack of self-efficacy (comfort with performing the required skills) or lack of outcome expectancy (belief that performance of a task will actually make a difference) [42]. In general, feedback can be as effective as educational interventions [44]. In a systematic review examining interventions to modify provider adherence to pediatric asthma guidelines, performance

feedback, decision support tools, and clinical pharmacy support were most likely to improve provider adherence to asthma guidelines as measured through health-care process outcomes [45]. There was limited evidence for organizational changes (interventions designed to change the way in which an organization provides care) and no benefits with education only or quality improvement [45].

Additionally, we found variability in the electronic integration and accessibility of pathways across hospitals. Some hospitals had developed EMR-based decision support, while others had no electronic accessibility of the pathway. Making clinical pathways electronically accessible requires time and resources, and it is not yet clear how to optimize incorporating this information into practice. A recent systematic review found no differences in guideline use comparing electronic versus printed guidelines, but increased use of electronic guidelines when they were accompanied by training or delivered via mobile device rather than a stationary, desktop computer. Authors found no evidence that the use of electronic guidelines translated into improved clinical practice or patient outcomes [46]. Future research should determine which mode of information delivery is most effective in improving clinical practice and patient outcomes, and whether centralized development of informational resources can improve the cost-effectiveness of the implementation process.

Lastly, we found very few hospitals used financial incentives as part of the pathway implementation process. Financial incentives are generally effective in improving processes of care, compliance with guidelines, and prescribing costs; however, there is no evidence that financial incentives improve patient outcomes [47]. For financial incentives to be successful, it will likely require larger incentives to motivate behavior change, incentive programs that are easy to understand and implement, and outcome metrics that are meaningful and motivating to providers [48]. In addition, in the inpatient setting, asthma care is delivered by a diverse team of providers; it may not be feasible to incentivize individual providers for implementation of a pathway that requires team-based care.

Our study utilized a large, national sample of hospitals that care for children to describe the utilization and implementation of clinical pathways. We described multiple aspects of pathway design and implementation in order to better guide future implementation efforts. One limitation of our analysis is that we were unable to obtain responses from 14% of PRIS hospitals, and these hospitals tended to be smaller, suburban, non-teaching, community hospitals. Since we found non-children's hospitals were less likely to implement pathways, we may be overestimating the proportion of hospitals that have implemented pathways. However, the high survey response

rates should minimize the risk of such selection bias. Another limitation of our study was variability in survey responses among respondents from the same hospital. This variability may reflect our use of generic terms in our survey questions (e.g. “Staff Training”), which may result in different interpretations by individual respondents. The overall validity of our analysis was strengthened by surveying multiple people from each hospital [25]. We handled conflicting responses by verifying data across sources (survey and pathway documents) and analyzing the data under the assumption that each respondent may have a specialized knowledge of the pathway that another respondent may not have [28]. Lastly, our study was limited to the PRIS network, which disproportionately consists of tertiary children’s hospitals, so our findings may have limited generalizability to community hospital settings. However, the PRIS network is the largest and most diverse network of US hospitals accessible for inquiry.

Conclusions

There has been a dramatic rise in hospitals implementing inpatient pediatric asthma pathways over the last ten years. However, there is a great deal of variation in pathway design and implementation across hospitals. Future study is needed to determine how to optimally design and implement pathways in the inpatient pediatric setting in order to better support hospital-level efforts in improving care and outcomes for children with asthma.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Appendix 1

Section 1

- (1) Please select your hospital from the drop-down list.
- (2) After children are admitted to your hospital for asthma, do health care providers use a clinical pathway or practice guideline to help guide management of their care during the hospitalization?
 - a. Yes
 - b. No
 - c. Not sure (consider soliciting input from others before marking “not sure”)

Section 2: (for those who answer “yes” to question #1)

The following questions are designed to provide more details on your inpatient asthma tool (e.g. clinical pathway, clinical practice guideline):

- (3) To the best of your ability, please select the year in which implementation of your hospital's inpatient asthma pathway/guideline started.
- (4) To the best of your ability, please select the quarter in which implementation of your hospital's inpatient asthma pathway/guideline started.
- (5) Please select which of the following health-care providers utilize your hospital's inpatient asthma pathway/guideline (Check ALL that apply):
 - a. Attending Physicians
 - b. Resident Physicians
 - c. Nurses
 - d. Nurse Practitioners
 - e. Respiratory Therapists
 - f. Case Managers
- (6) Please select from the following descriptions of how the inpatient asthma pathway/guideline is accessed electronically (Check ALL that apply):
 - a. Providers can choose to access the pathway/guideline on screen outside of your hospital's electronic health record/EHR (e.g. external website)
 - b. Providers can choose to access the pathway/guideline within your hospital's HER
 - c. Providers are guided to the pathway/guideline by EHR-driven decision support for patients admitted for asthma
 - d. The pathway/guideline within the EHR guides appropriate orders within a single workflow
 - e. The pathway/guideline within the EHR guides appropriate orders within a single workflow based on the patient's current clinical condition (e.g. respiratory score)
 - f. The pathway/guideline within the EHR guides appropriate escalation and prompts de-escalation of treatment based on the patient's current clinical condition (e.g. respiratory status)
 - g. None of the above/not electronically accessible
 - h. Other [please specify below]
 - i. Not sure (consider soliciting input from others before marking “not sure”)
- (7) If you answered “Other,” please describe.

If you answered b, c, d, e, or f—

- (8) Please select the year in which your hospital's inpatient asthma pathway/guideline was integrated into your EHR.
- (9) Please select the EHR system currently used by your hospital.
 - a. Epic
 - b. Allscripts
 - c. eClinicalWorks
 - d. NextGen
 - e. GE Healthcare Cerner
 - f. Other
- (10) Please indicate if your inpatient asthma pathway/guideline contains the following elements (Check ALL that apply):

- a. Detailed guidance on elements to be assessed to determine severity of asthma exacerbation (e.g. vital signs, respiratory exam, peak expiratory flow)
 - b. Medication guidance (indication, dosage, frequency)
 - c. Detailed time-based steps to guide treatment titration
 - d. Instructions for nurses or respiratory therapists to titrate treatment
 - e. Signs of clinical deterioration/worsening
 - f. Indications for subspecialist consultation
 - g. Checklist of items for discharge planning (e.g. arrangement of outpatient follow-up visit)
 - h. Quality metrics being monitored
 - i. Citations of primary literature
 - j. Costs of medications or therapies
 - k. Cost-effective alternatives to common therapies or medications
- (11) Does your hospital actively track compliance with the inpatient asthma pathway/guideline?
 - a. Yes
 - b. No
 - c. Not sure (consider soliciting input from others before marking "not sure")
 - (12) Currently, what percentage of children hospitalized for asthma at your institution receive most or all of their asthma care based on the pathway/guideline, as opposed to "provider discretion"?
 - a. <25%
 - b. 25–50%
 - c. 50–75%
 - d. >75%
 - e. Not sure (consider soliciting input from others before marking "not sure")
 - (13) How has use of the pathway/guideline by providers caring for children hospitalized with asthma changed over time
 - a. It has increased
 - b. It has decreased
 - c. It has stayed the same
 - d. Not sure
 - (14) Have there been efforts to increase compliance with use of the pathway/guideline?
 - a. Yes
 - b. No
 - c. Not sure
 - (15) If yes, please describe.
 - (16) Which of the following factors were utilized for dissemination and implementation of the inpatient asthma pathway? (Check ALL that apply)
 - a. Provider champion/leader
 - b. Training/Education of Staff
 - c. Performance Feedback
 - d. Support of Administration/Hospital Leaders
 - e. Financial Incentives for Providers
 - f. Not sure
 - (17) Please use this space to add any additional factors you feel were important for dissemination and implementation of the inpatient asthma pathway.
 - (18) Since there is variability in how institutions define pathways and guidelines, we ask you to provide a copy of

whatever tool your institution uses for our study group to review. Please upload your hospital's inpatient asthma pathway or guideline here.

- (19) If your hospital's pathway/guideline is publicly accessible online, please provide the web URL for accessing the document.

Section 3: Done by all participants

The following questions are about other factors that may affect inpatient asthma care:

- (20) Do health-care providers at your hospital use any other tools in the management of children hospitalized with asthma? (Check ALL that apply)
 - a. *Order Set* (standardized list of orders for children hospitalized with asthma)
 - b. *Pocket Card* (portable short summary document that providers can use as a quick reference to help guide inpatient asthma care)
 - c. Other (please specify)
 - d. None of the above
- (21) If you answered "Other," please describe
- (22) Does your hospital have any clinical pathways or guidelines for other common pediatric conditions (e.g. pneumonia, bronchiolitis)?
 - a. Yes
 - b. No
 - c. Not sure
- (23) Does your hospital have a short-stay unit where asthmatic patients are admitted?
 - a. Yes
 - b. No
 - c. Not sure
- (24) Does your hospital have a Quality Improvement Director/Officer?
 - a. Yes
 - b. No
 - c. Not sure
- (25) Does your hospital have a clinical pathway or guideline for management of children with asthma prior to inpatient hospitalization, such as in ambulatory/outpatient settings or the emergency department?
 - a. Yes
 - b. No
 - c. Not sure
- (26) The following questions are meant to assess your hospital's cultural competence policies. Please check ALL that apply.
 - a. My hospital recruits ethnically diverse nurses and providers.
 - b. My hospital recruits bilingual nurses and providers.
 - c. My hospital attempts to minimize cultural barriers through printed materials.
 - d. My hospital offers cross-cultural or diversity training.
 - e. My hospital offers training to providers to develop communication skills.
 - f. My hospital evaluates the level of cultural competence among providers.
 - g. My hospital offers access to interpreters.

- h. My hospital provides interpreter service via telephone.
 - i. My hospital provides low-literacy health educational materials.
- (27) Does your hospital offer any of the following outpatient resources for children with severe asthma?
- a. Specialized asthma outpatient clinics
 - b. Case/care management services
 - c. Asthma education programs
 - d. Environmental Assessments of Homes
 - e. Smoking Cessation Support for Parents
 - f. Other (please specify)
 - g. Not sure
- (28) Which of the following best describes you?
- a. Physician
 - b. Nurse
 - c. Nurse practitioner
 - d. Respiratory therapist
 - e. Administrator
 - f. Other [please describe]
- (29) What is your primary role at your institution?
- a. Clinical
 - b. Administrative
 - c. Research
 - d. Quality/Safety
 - e. Other (please describe)