Improving Pediatric Asthma Outcomes in a Community Emergency Department

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Dr Walls conceptualized and designed the study, met with key stakeholders in the quality improvement process, performed data analysis, and drafted the initial manuscript; Dr Hughes designed the data collection instruments, collected data, met with key stakeholders in the quality improvement process, and reviewed and revised the manuscript; Dr Mullan performed data analysis and critically reviewed and revised the manuscript; Dr Chamberlain contributed to the design of the study and the statistical analysis plan and critically reviewed and revised the manuscript; Dr Brown designed the intervention for the quality improvement initiative and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

BACKGROUND: Asthma triggers >775 000 emergency department (ED) visits for children each year. Approximately 80% of these visits occur in community EDs. We performed this study to measure effects of partnership with a community ED on pediatric asthma care.

METHODS: For this quality improvement initiative, we implemented an evidence-based pediatric asthma guideline in a community ED. We included patients whose clinical impression in the medical decision section of the electronic health record contained the words asthma, bronchospasm, or wheezing. We reviewed charts of included patients 12 months before guideline implementation (August 2012–July 2013) and 19 months after guideline implementation (August 2013–February 2015). Process measures included the proportion of children who had an asthma score recorded, the proportion who received steroids, and time to steroid administration. The outcome measure was the proportion of children who needed transfer for additional care.

RESULTS: In total, 724 patients were included, 289 during the baseline period and 435 after guideline implementation. Overall, 64% of patients were assigned an asthma score after guideline implementation. During the baseline period, 60% of patients received steroids during their ED visit, compared with 76% after guideline implementation (odds ratio 2.2; 95% confidence interval, 1.6–3.0). After guideline implementation, the mean time to steroids decreased significantly, from 196 to 105 minutes (P < .001). Significantly fewer patients needed transfer after guideline implementation (10% compared with 14% during the baseline period) (odds ratio 0.63; 95% confidence interval, 0.40–0.99).

CONCLUSIONS: Our study shows that partnership between a pediatric tertiary care center and a community ED is feasible and can improve pediatric asthma care.

Asthma is a common disease of childhood, affecting nearly 7 million children in the United States and triggering >775 000 emergency department (ED) visits for children each year.1–2 National guidelines for the emergency care of children with asthma and quality indicators for pediatric asthma in the ED have been published and include timely administration of oral corticosteroids and decreasing ancillary testing such as chest radiographs.3–7 Despite these guidelines, there is significant variation in the emergency treatment of children with asthma, and many EDs fall short of achieving recommended therapies.5–12 Community EDs that see low numbers of children may lack necessary resources or familiarity with pediatric asthma to comply with national
guidelines. Nearly 70% of EDs in the United States see <14 children per day. Only 33% of US EDs reported the ability to care for a 6-year-old patient with an asthma exacerbation of any severity. Children seen for asthma in general EDs are less likely to receive corticosteroids in compliance with National Institutes of Health (NIH) guidelines compared with those seen in pediatric EDs. Children seen in general EDs are also more likely to receive unnecessary testing and treatment. Use of asthma pathways can increase adherence to NIH asthma guidelines and improve quality and efficiency of care for children who present to the ED with asthma. However, previous studies were performed in academic or pediatric-specific EDs. Given that ~80% of pediatric ED visits in the United States occur in general or community EDs, it is important that quality improvement efforts for the emergency care of children with asthma include community hospitals to improve the care of as many children as possible. A disproportionately larger number of children in the Washington, DC area have asthma compared with other US regions, with 12.6% of children diagnosed with asthma in the district, compared with 9.0% nationwide. In our tertiary care pediatric ED, >6% of our annual 87 000 ED visits are for asthma-related illnesses. These numbers include children who begin their care in a community ED and need transport to our facility for additional care (>400 children in 2014).

In 2007, we implemented a pediatric asthma pathway in our ED. The pathway resulted in significant improvements in the emergency care of children with asthma, including decreased time to steroids, decreased emesis after steroid administration, and decreased admission rates (unpublished data).

In 2012, a community ED in our area reached out to our staff for assistance in starting a pediatric quality improvement initiative. They were motivated by recent completion of the National Pediatric Readiness Survey and a desire to decrease the number of children needing transfer from their ED for additional care. Because of the high prevalence of asthma in our area and the availability of national guidelines for the treatment of children with this disease, we formed a partnership with the community ED to focus on improving their emergency care of children with asthma.

We collaborated with a multidisciplinary team of providers in the community ED to adapt our pathway to their site. We aimed to improve the care of their pediatric asthma patients by introducing an asthma score, increasing the proportion of patients receiving steroids, decreasing time to steroid administration, and decreasing the proportion of patients who needed transfer for additional care.

**METHODS**

This study was approved by the institutional review board (IRB) at our institution and met criteria for waiver of informed consent. Because they do not have their own IRB, the leaders of the community hospital agreed to use our IRB to review our quality improvement initiative and follow its recommendations and decisions.

**Context**

We performed our study in a community ED that sees ~55 000 patients per year, of whom 20% are <18 years old. This ED is staffed by board-certified emergency medicine physicians, nurse practitioners, and physician assistants. The community hospital does not have pediatric inpatient beds or pediatric specialists. Children who need hospital admission or subspecialty care are transferred from the community ED to our tertiary care pediatric hospital. Before our partnership, the community ED had evidence-based guidelines in place for several adult illnesses (eg, suspected myocardial infarction, stroke, and sepsis). These guidelines are either attached to the patient’s chart in paper form or available in the electronic health record (EHR) as a suggested order set. Quality improvement metrics based on these existing guidelines are reported to ED staff at meetings and on an information board in the department.

**Intervention**

The intervention for this quality improvement initiative was implementation of an evidence-based pediatric asthma pathway in a community ED. The pathway mirrors 1 used in our institution, which was designed by faculty in our ED and hospitalist divisions according to best evidence practice. In addition to providing decision support in a form that is familiar to community ED staff, we used change concepts to facilitate improvement. A change concept is an “approach to change found to be useful in developing specific ideas for changes that lead to improvement.”

We used change concepts of standardization, development of operational definitions, and moving steps in a process closer together. A key component of the pathway is documentation of an asthma score (Table 1), which provides standardization and an operational definition for providers. This score was adapted from several previously validated scores and modified to allow easier communication between nurses, physicians, and respiratory therapists in our ED and on inpatient wards. Scores range from 0 to 10, with ≥4 considered moderate to severe. We applied the concept of moving steps in a process closer together by providing nurse-initiated therapies for patients, including the early use of bronchodilators and...
corticosteroids. Early administration of steroids leads to increased efficiency of care and decreased hospitalization rates for children presenting to the ED with asthma.\textsuperscript{22,23}

At our institution, the pathway is part of the EHR and can be initiated by nurses in triage or by providers in the ED.

Our multidisciplinary partnership included key stakeholders in the community ED: nurses, respiratory therapists, pharmacists, physicians, nurse educators, and the medical director. Before implementation, we met to discuss how to best integrate the pathway into their ED and to address potential barriers. Based on input from these meetings, we opted to incorporate the pathway into their EHR, but we split the pathway into a triage order set and a provider order set, mirroring care practices currently in place for other conditions in their ED. As at our institution, patients were eligible for the pathway regardless of the asthma score. Several adjustments were made in the community ED to facilitate compliance with the pathway. These adjustments included increasing availability of respiratory therapists to administer multiple doses of bronchodilators to patients with severe asthma, making additional medications (e.g., dexamethasone) available from the pharmacy, and moving a medication dispensing system to the triage area for earlier initiation of treatment.

Figure 1 shows the final version of the pathway incorporated into the community ED EHR.

In addition to incorporating the pathway into the EHR, we met with staff in the community ED to educate them about the evidence supporting it. One of our nurses met with nurse educators at the community ED to train them on assigning an asthma score; the nurse educators then trained the community ED nursing staff on the asthma score and the new pathway. Nurses also

### TABLE 1 Pediatric Asthma Score

<table>
<thead>
<tr>
<th>Respiratory rate</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–3 y</td>
<td>≤34</td>
<td>35–39</td>
<td>≥40</td>
</tr>
<tr>
<td>4–5 y</td>
<td>≤30</td>
<td>31–35</td>
<td>≥36</td>
</tr>
<tr>
<td>6–12 y</td>
<td>≤26</td>
<td>27–30</td>
<td>≥31</td>
</tr>
<tr>
<td>&gt;12 y</td>
<td>≤23</td>
<td>24–27</td>
<td>≥28</td>
</tr>
<tr>
<td>Room air oxygen saturation</td>
<td>&gt;83%</td>
<td>89%–83%</td>
<td>≤88%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Auscultation</th>
<th>Normal breath sounds</th>
<th>Expiratory wheeze</th>
<th>Inspiratory and expiratory wheeze or diminished breath sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retractions</td>
<td>≤1 accessory muscle\textsuperscript{a}</td>
<td>2 accessory muscle\textsuperscript{a}</td>
<td>≥3 accessory muscle\textsuperscript{a}</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>None</td>
<td>Mild to moderate</td>
<td>Severe</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Accessory muscle use includes nasal flaring, suprasternal, intercostal, and substernal retractions.

### Triage Order Set

- **Nursing Interventions**
  - Continuous pulse ox monitoring
  - Peripheral IV start
- **Medications**
  - For patients <30 kg:
    - Continuous ipratropium 0.5 mg ×1; FIRST ROUND ONLY
    - Continuous albuterol 7.5 mg ×1
  - For patients >30 kg:
    - Continuous ipratropium 1 mg ×1; FIRST ROUND ONLY
    - Continuous albuterol 15 mg ×1
    - Dexamethasone [Decadron 6 mg for ped pts 7–10 kg PO]
    - Dexamethasone [Decadron 10 mg for ped pts 11–20 kg PO]
    - Dexamethasone [Decadron 16 mg for ped pts 21 kg and above PO]

### Provider Order Set

- **Interventions**
  - Continuous pulse ox monitoring
  - Consider consult other facility
- **Medications**
  - Albuterol 0.083% INH Solution 7.5 mg/15 mg via neb
  - Ipratropium 0.02% INH Solution 0.5 mg/1 mg via neb
  - Dexamethasone
    - 6 mg PO once
    - 10 mg PO once
    - 16 mg PO once
  - Additional nebulized medications
    - Albuterol 0.083% INH Solution
      - 2.5 mg via neb
      - 5 mg via neb
      - 7.5 mg via neb
  - Additional medications
    - Magnesium sulfate 50%
      - See dose instructions
    - Epinephrine
      - See dose instructions
    - Methylprednisolone succinate
      - See dose instructions

### FIGURE 1

Asthma pathway for community emergency department. INH, inhalation; IV, intravenous; neb, nebulizer; ox, oximeter; ped pts, pediatric patients; PO, by mouth.
received a quick reference card with the asthma scoring system. Two of the investigators (T.A.W., N.T.H.) presented the pathway to community ED providers at physician staff meetings to familiarize them with the pathway. One investigator (N.T.H.) worked with the community ED pharmacist to ensure availability and proper dosing of medications in the order sets. The lead investigator (T.A.W.) also met with information technology (IT) in the community ED to assist in incorporating the pathway into their order sets. The community ED implemented the pathway in August 2013. After pathway implementation, nurses received additional training on the asthma scoring system at annual skills days (September 2013 and 2014). In March 2014, we surveyed community ED staff for feedback on the pathway. We presented survey results and preliminary outcome measures to ED physicians in May 2014. Table 2 shows the timeline for events leading up to and following pathway implementation.

**Study of the Intervention**

To find eligible patients, we reviewed all charts of children ages 2 to 17 years who presented to the community ED. In their EHR, providers enter a clinical impression after initial evaluation and before discharge diagnosis. We included patients in our analyses if the provider documented a clinical impression of “wheezing,” “asthma,” or “bronchospasm.” We found that the chief complaint was not sensitive, and International Classification of Diseases, Ninth Revision codes for discharge diagnoses were not specific, often including asthma or wheezing even if the patient presented to the community ED for a complaint that was not asthma-related and the child had no respiratory findings on examination. Using the clinical impression gave us the most accurate representation of patients for whom the pathway would be relevant.

We reviewed charts of patients 12 months before pathway implementation (August 2012–July 2013) and 19 months after pathway implementation (August 2013–February 2015).

**Measures**

Process measures included the proportion of children who had an asthma score recorded, the proportion who received steroids, and for those who received steroids, time from triage arrival to steroid administration. The outcome measure was the proportion of children who needed transfer for additional care. As a balancing measure, we examined the proportion of patients with asthma-related visits to the community ED within 7 days of the patient’s initial ED visit. A return visit was considered asthma-related if the clinical impression contained the words asthma, bronchospasm, or wheezing, mirroring criteria for inclusion of the initial ED visit.

**Analysis**

Our primary statistical analyses were based on statistical process control methods to demonstrate changes in our process and outcome measures over time.24 We set control limits at 3 standard deviations from the mean and used standard criteria to determine special cause variation.25 To analyze return visits, we compared proportions before and after the intervention by using the $\chi^2$ test. Our secondary analyses included calculation of odds ratios (ORs) and $P$ values based on the $\chi^2$ test for proportions and $P$ values based on the 2-tailed $t$ test for time analyses. A $P$ value of $<.05$ was considered significant.

**RESULTS**

There were 724 patients included (4.4% of all visits by patients aged 2–17 years), 289 during the baseline period and 435 after pathway implementation. Overall, 64% of patients were assigned an asthma score after pathway implementation. During the baseline period, 60% of patients received steroids during their ED visit, compared with 76% after pathway implementation (OR 2.2; 95% confidence interval, 1.6–3.0; $P < .0001$). The proportion of patients who received steroids over time is shown in Fig 2. A significant shift in the centerline was noted in the p-chart during the implementation period, with a special cause variation noted in April 2014 (≥9 points above the baseline centerline). After pathway implementation, the mean time to steroids decreased significantly, from 196 minutes to 105 minutes ($P = .00001$). A significant shift in the centerline was noted in the X-bar chart (Fig 3) during the implementation period, with a special cause variation noted.

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**TABLE 2 Calendar of Events for Implementation of the Pediatric Asthma Pathway**

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>August</td>
<td>Introductory meeting with CED nursing</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>Introductory meeting with CED providers</td>
</tr>
<tr>
<td>2013</td>
<td>February</td>
<td>CED nursing training begins</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>Meeting with CED IT</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>Meeting with CED pharmacy</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>Preimplementation meeting with all CED stakeholders</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>Pathway “live”</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>Continued CED nursing education</td>
</tr>
<tr>
<td>2014</td>
<td>March</td>
<td>CED staff survey about pathway</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>Preliminary results presented to CED providers</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>Continued CED nursing education</td>
</tr>
</tbody>
</table>

CED, community emergency department.
Significantly fewer patients needed transfer for additional care after the pathway was implemented (10% compared with 14% during the baseline period) (OR 0.63; 95% confidence interval, 0.40–0.99; \( P = .046 \)). A significant shift in the centerline was noted in the p-chart during the implementation period, with a special cause noted in February 2015 (≥9 points of data below the baseline centerline) (Fig 4).

There were no significant differences in return rates for patients seen during the baseline period and those seen after pathway implementation (2.8% vs 1.1%, \( P = .12 \)).

**DISCUSSION**

We formed a partnership between our tertiary care pediatric ED and a community ED to improve the emergency care of children with asthma by using an evidence-based asthma pathway adapted from the tertiary institution. After they implemented our pediatric asthma pathway, more children in their ED received steroids, time to steroid administration was shortened, and fewer children needed transfer for additional care.

Participation of staff from multiple disciplines in the community ED (nursing, pharmacy, respiratory therapy, IT) was key to the success of this partnership. Involving all members of the health care team gave us valuable insight into patient care in the community ED and increased buy-in from the providers there. However, differences in charting practices and EHR systems, as well as distance between tertiary and community clinical environments, made doing a quality improvement initiative at a separate site difficult.

We found 1 study that addressed improving the care of emergency pediatric patients via outreach to a community ED.26 A pediatric ED in Australia studied a partnership with 1 of their general EDs. Interventions included construction of a pediatric-specific treatment area, appointment of a physician and nurse in the general ED to provide pediatric education and training, and development and
implementation of pediatric practice guidelines for common conditions. They documented improvements in clinical care (increased vital sign documentation, pain control, and adherence to asthma guidelines), parent satisfaction, and staff satisfaction in caring for children at the general ED after the partnership was formed. We found no similar studies in the United States or elsewhere.

Evidence for the use of practice guidelines for the emergency care of children with asthma is strong. Two separate studies found increased steroid administration, decreased time to steroids, and decreased hospitalization rates in children with asthma who were treated according to an asthma pathway. At our institution, a nurse-initiated asthma pathway also resulted in decreased time to steroid administration and fewer hospital admissions (unpublished data).

Although these studies demonstrate how pediatric asthma pathways can improve emergency care for children with asthma, they took place in academic or pediatric centers. In contrast, the overwhelming majority of children who visit an ED in the United States are not treated at academic pediatric specialty hospitals. Evidence from physician surveys shows that clinical pathways are well received by providers in general EDs. However, many community EDs report barriers to successful implementation of pediatric pathways, including limited educational resources, lack of an ED champion health care provider with pediatric expertise, lack of pediatric-specific quality improvement plans, and lack of appropriate pediatric training for nurses and physicians. The American Academy of Pediatrics, the American College of Emergency Physicians, and the Institute of Medicine have also emphasized the need for quality improvement measures and research in pediatric emergency care. Reaching out to community EDs via shared pathways and quality improvement initiatives complies with these recommendations. In addition, partnerships with community EDs can help translate important research findings to the community, thus having a broader impact on the emergency care of children. Our study is the first to document a quality improvement collaborative between a tertiary care pediatric ED and a community ED in the United States.

Our study has some limitations. Only 64% of patients had an asthma score recorded during the implementation period. The majority of patients in our study who were assigned an asthma score had mild to moderate asthma (score of <4) on presentation to the community ED (229 in 279, or 82%). Triage nurses or ED providers may have been less likely to document a low score or to order corticosteroids for these patients. Previous studies of pediatric asthma pathways have generally limited their subjects to those with moderate to severe asthma. Reports on benchmarks for the emergency care of children with asthma also emphasize the care of children with moderate to severe asthma. However, the definition of moderate to severe asthma is not consistent in the literature. Some studies use a scoring system, whereas others use the number of bronchodilator treatments to assign asthma severity.

The National Heart, Lung, and Blood Institute Asthma Guidelines recommend oral corticosteroids for patients who do not respond immediately and completely to bronchodilators. We chose to include all asthma-related visits in our analyses. We did not limit use of the pathway based on the asthma score, nor could we determine whether a child presented with wheezing for the first time. Therefore, we may have overestimated the number of...
children who should have received corticosteroids according to NIH guidelines.

We could capture return visits only to the community ED, not to other emergency facilities or clinics in the area. Therefore, our return rates may not reflect all children who returned for asthma care after being seen in the community ED.

It is possible that other factors contributed to the improvements in pediatric asthma care in the community ED. We could not account for potential variation in the severity of respiratory illnesses in the community over time, patient use of controller medications for asthma, or changes in community ED staff.

Finally, the specifics of our partnership may not be generalizable to other community EDs, because systems differ and key stakeholders may vary in other settings.

Despite these limitations, we were able to show improvements in the pediatric emergency care of asthma in a community ED. Our improvements were sustainable for >1 year and over 2 respiratory seasons. This unique partnership brings quality improvement to where most children receive emergency care in the United States: the community ED.

**CONCLUSIONS**

Our study shows that partnership between a pediatric tertiary care center and a community ED is feasible and can improve community-based pediatric asthma care. We plan to continue our partnership and work to improve the emergency care of children with other illnesses, such as gastroenteritis and fever. Because the overwhelming majority of pediatric emergency visits occur in community EDs, partnerships with these EDs can broaden the impact of quality improvement activities and should be part of future quality improvement efforts.

**ACKNOWLEDGMENTS**

The authors thank Christine Rawlinson and Dr Satyam Vashi for their assistance in planning and implementing this quality improvement initiative.

**ABBREVIATIONS**

CI: confidence interval  
ED: emergency department  
EHR: electronic health record  
IRB: institutional review board  
IT: information technology  
LCL: lower control limit  
NIH: National Institutes of Health  
OR: odds ratio

**REFERENCES**

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