Impact of a Bronchiolitis Guideline*
A Multisite Demonstration Project

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Study objectives: The purpose of this study was to determine the impact of a multisite implementation of an evidence-based clinical practice guideline for bronchiolitis.

Design: Before and after study.

Setting: Eleven Child Health Accountability Initiative (CHAI) study hospitals.

Patients: Children < 12 months of age with a first-time episode of bronchiolitis.

Intervention: The guideline was implemented in December 1998. Complete preimplementation and postimplementation administrative data on hospital admissions, resource utilization, and length of stay were available from seven study hospitals. At five sites, chart reviews were conducted for data on the number and type of bronchodilators used.

Measurements and results: Complete administrative data were available for 846 historical control subjects and 792 study patients. Length of stay decreased significantly. While the proportion of eligible patients who received any bronchodilator did not change (84%), the proportion of patients who received albuterol decreased from 80 to 75% after guideline implementation (p < 0.03). For patients who received bronchodilators, the mean (± SD) number of doses decreased from 13.6 ± 14.0 to 7.3 ± 9.1 doses (p < 0.0001). For patients who received albuterol, the mean number of doses decreased from 12.8 ± 11.8 to 6.4 ± 7.8 doses (p < 0.0001). Other resource use decreased modestly. Hospital readmission rates within 7 days of discharge were unchanged.

Conclusions: We successfully extended the implementation of an evidence-based clinical practice guideline from one hospital to seven hospitals. Within just a single bronchiolitis season, some significant changes in practice were seen. The multisite CHAI collaborative appears to be a promising laboratory for large-scale quality improvement initiatives.

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Key words: bronchiolitis; guideline; multi-site demonstration

Abbreviations: CHAI = Child Health Accountability Initiative; PHIS = Pediatric Health Information System; RSV = respiratory syncytial virus

Bronchiolitis is the most common lower respiratory tract infection in infants. Primarily caused by infection with the respiratory syncytial virus (RSV), bronchiolitis is most commonly characterized by a first-time episode of wheezing in infants.1–2

While significant morbidity is infrequent, bronchiolitis accounts for approximately 17% of all hospitalizations of infants.3–4

In the past, only supportive care of these patients was generally recommended. However, during the last decade, inhalation therapies using β-agonists became popular, in part because of the difficulty in distinguishing between the wheezing caused by infection-induced airway edema in bronchiolitis and that associated with allergy-produced inflammation and bronchospasm characteristic of asthma. Despite numerous randomized clinical trials and meta-analyses of these trials raising serious doubt about the therapeutic efficacy, these aggressive therapies have remained prevalent.5–16

Variation in the use of therapies unrelated to individual patient characteristics or illness severity...
was first described by Wennberg and Gittelsohn. They speculated that significant reductions in the resource utilization, without reductions in the quality of care, could be achieved by reducing inappropriate variation caused by “practice styles.” These variations have also been documented in the pediatric field and may result in differences in hospitalization rates as well as the use of specific therapies. The use of evidence-based practice guidelines based on scientific evidence has emerged as a tool to address both quality and cost by applying scientific knowledge to reduce variation.

This article describes the multisite implementation of an evidence-based clinical practice guideline for children hospitalized with bronchiolitis at member hospitals of the Child Health Accountability Initiative (CHAI). The CHAI was developed in 1997 as a partnership of chief executive officers, physicians, and health-services researchers from children’s hospitals and health systems to evaluate options for collectively developing pediatric outcomes. The goals of the collaborative are: (1) to design, evaluate, and implement national measures of quality of care and health outcomes for children, using hospitals that care for children as learning laboratories; and (2) to undertake collaborative projects and research to promote clinical practices that lead to improved health outcomes for children. We present here the results of the implementation of key diagnostic and therapeutic interventions and identify factors that contributed to successful guideline implementation for in-hospital care of children with bronchiolitis.

MATERIALS AND METHODS

Guideline Development

The evidence-based guideline for hospital-based bronchiolitis care used in this study had been previously developed and tested at a single site. This initial guideline was developed by a multidisciplinary team comprised of community physicians, hospital staff pediatricians, a chief resident, a pulmonologist, a respiratory therapist, nurses, and health-care professionals responding to a call to produce a guideline that reflected scientifically defensible “best practices” and discouraged indiscriminant variations in care caused by the use of unproven or nonbeneficial methods and therapies. The team explored existing literature on the etiology, pathophysiology, prognosis, evaluation, and care of bronchiolitis patients. The literature was divided into sections by category, with team members assigned to review each section, grade each article, and summarize the results. At each meeting, results were then presented back to the entire committee for discussion and identification of best practices based in evidence. More than 200 articles from refereed journals were identified and reviewed. Each article was first characterized using an internally developed grading scale and then critically assessed for scientific merit. The team also explored existing guidelines and national and local experiences before formulating their recommendations.

It was intended that use of the guideline would remain voluntary and totally at the discretion of the practitioner. Results from the single test site have been previously described and supported our premise that evidence-based approaches can improve patient outcomes and reduce costs.

This previously tested bronchiolitis guideline was provided in its original form to scientific directors at each of the participating CHAI hospitals. Minor modifications to the original guideline were made after consultation with the clinical champions at each member institution to increase “buy-in” at each site.

Along with the guideline, a pathway and order sheet were available to each study site. Use of any of these documents was voluntary and varied among the study hospitals based on the institutions’ prior use of guidelines and pathways, as well as their prior approaches to treating bronchiolitis (Table 1). In one study hospital, the set of physician orders generated was incorporated into the clinical order entry system.

Guideline Content

The scope of the guideline was limited to the care of infants < 1 year of age who were admitted to the hospital with a first-time episode of typical bronchiolitis. Selecting only infants with first-time disease reduced the likelihood of including patients with asthma. Excluded from eligibility were infants with histories of immunodeficiencies, significant congenital heart diseases, bronchopulmonary dysplasia, congenital airway diseases, or any other comorbid condition that might make the effect of the bronchiolitis more severe and, thereby, make the care more complicated. Patients requiring use of ventilator or other intensive therapies were also excluded.

The guideline states that “typical bronchiolitis in infants is a self-limited disease, usually caused by an acute viral infection that is little modified by aggressive evaluations, use of antibiotics, or other therapies.” Thus, the goals of treatment were to ensure that the patient was well oxygenated and well hydrated. The guideline

<table>
<thead>
<tr>
<th>Site</th>
<th>Practice Guideline</th>
<th>Standard Orders</th>
<th>Pathway</th>
<th>Parent Education</th>
<th>Respiratory Scoring System</th>
<th>Guideline Use, %</th>
</tr>
</thead>
<tbody>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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</tr>
<tr>
<td>B</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
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</tr>
<tr>
<td>C</td>
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<td>No</td>
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<td>Yes</td>
<td>No</td>
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</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>F</td>
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<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>84.0</td>
</tr>
<tr>
<td>G</td>
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<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>86.9</td>
</tr>
<tr>
<td>Overall</td>
<td>5/7</td>
<td>3/7</td>
<td>4/7</td>
<td>5/7</td>
<td>2/7</td>
<td>77.8</td>
</tr>
</tbody>
</table>
noted the lack of evidence for routine use of diagnostic tests such as radiographs, blood gas analysis, and nasopharyngeal wash for RSV and the lack of benefit from routine use of therapies, such as chest physiotherapy, cool mist, supervised cough and suction, saline solution aerosol, and steroid inhalations. The guideline suggested that a trial of inhalations using racemic epinephrine be considered in very select patients. Routine use of bronchodilator aerosol therapies was not recommended. However, if inhalation therapy was tried, the guideline recommended objective assessment of the therapeutic benefit using a standardized respiratory score. Discontinuation of inhalation therapy was recommended if no significant improvement in clinical appearance was observed between 30 min and 60 min after a trial inhalation therapy. The guideline also recommended supplemental oxygen if oxygen saturation was ≤ 90%, and IV fluid if dehydrated.

The main recommendations of the guideline are summarized in Table 2. A summary of the guideline is available at the National Guideline Clearinghouse Web site (http://www.guideline.gov/index.asp).

**Study Hospitals**

The guideline was implemented in 11 CHAI study hospitals in December 1998. Participating CHAI Hospitals included Arkansas Children’s Hospital, Little Rock, AR; Camcare Health Systems, Inc. and the Women and Children’s Hospital, Charleston, WV; Children’s Hospital of Buffalo, Buffalo, NY; Children’s Hospital and Health Center, San Diego, CA; Children’s Hospital of the King’s Daughter’s Health System, Norfolk, VA; Children’s Hospital Medical Center, Cincinnati, OH; Children’s Hospital of Wisconsin, Milwaukee, WI; Children’s Hospital of Los Angeles, Los Angeles, CA; Children’s National Medical Center, Washington, DC; Le Bonheur Children’s Medical Center, Memphis, TN; and Lucile Packard Children’s Health Services, Palo Alto, CA. Hospitals that provided complete data from their financial and clinical computer systems included Arkansas Children’s Hospital, Camcare Health Systems, Inc. and the Women and Children’s Hospital, Children’s Hospital of the King’s Daughter’s Health System, Children’s Hospital Medical Center, Children’s Hospital of Wisconsin, Children’s Hospital of Los Angeles, and Children’s National Medical Center. Hospitals that also provided data from chart reviews of the same patients included Arkansas Children’s Hospital, Camcare Health Systems, Inc. and the Women and Children’s Hospital, Children’s Hospital Medical Center, Children’s Hospital of Wisconsin, and Children’s Hospital of Los Angeles.

One hospital discontinued implementation of the guideline because of physician opposition, while another hospital focused exclusively on patients admitted through the emergency department. Two other hospitals were excluded from this report because of incomplete data collection. Thus, complete preimplementation and postimplementation data on hospital admissions, resource utilization ancillary to bed occupancy, and length of hospitalization were available from only seven study hospitals. At five of the seven study hospitals, data from administrative databases were supplemented with data obtained from chart review. These chart reviews were conducted to obtain selective data not available in the administrative data. These selective data focused on the number and type of bronchodilators used and formed the primary data to analyze the impact of the guideline on bronchodilator use.

### Table 2—Bronchiolitis Guideline Highlights

**Overview**

- It is recommended that bronchiolitis, in typical presentation, be viewed as a self-limited disease characterized by airway edema and not bronchospasm.  
- The basic management of bronchiolitis is anchored in the provision of therapies that ensure that the patient is well oxygenated and well hydrated.  
- Laboratory and radiologic studies:
  - Routine nasopharyngeal washing for RSV antigen is not recommended.  
  - Chest radiographs are not recommended as routine.  
  - Blood gas analyses are recommended only as needed for individual patients (no evidence; expert opinion or consensus).

**Respiratory care therapies**

- Chest physiotherapy is not recommended.  
- Cool mist therapy is not recommended.  
- Supervised cough and suction is not recommended.  
- Aerosol therapy with saline solution is not recommended.  
- Steroid inhalations are not recommended.  
- Routine use of bronchodilator aerosol therapies is not recommended.  
- Inhalations using racemic epinephrine may be considered in selected patients.  
- If, within 60 min of a trial inhalation therapy, there is not significant improvement, it is recommended that the therapy not be repeated.

**Monitoring**

- Discontinue electronic monitoring in timely manner to help transition to home (no evidence; expert opinion or consensus).

**Isolation**

- Respiratory/contact isolation using 1 week cohorting (no evidence; expert opinion or consensus).

**Guideline Implementation**

Standardized educational strategies based on the literature were recommended to the study hospitals. These included the following:

1. Education via medical grand rounds, presentation at meetings of community primary care physicians, house staff training sessions, nursing training forums, poster displays, and hospital news publications;
2. Inclusion at daily rounds of a study coordinator to track eligible patients, reinforce guideline principles, and resolve any problems inhibiting guideline implementation;
3. Identification of a physician champion at each site to support the necessary change. Each site implemented some or all of these education strategies, again based on the culture of the individual institution. All sites had an identified physician champion and a study coordinator.

**Study Population**

The study population consisted of all infants < 12 completed months of age with a first-time episode of bronchiolitis, admitted to any one of the study hospitals between December 15, 1998, and March 31, 1999. Patients with an ICU admission at any time during their stay were excluded. Eligible patients during the guideline period were identified daily by review of emergency department and hospital admission logs, and confirmed by manual chart review and consultation with the physician caring for the infant. Infants with a history of chronic illness, such as congenital heart disease, broncho-pulmonary dysplasia, cystic fibrosis, or immunodeficiency requiring ventilatory support, were excluded.

Infants with a principal discharge diagnosis code of 466.1x and an All Patient Refined Diagnosis Related Group classification of 096, 676, or 655 were identified following the study period from administrative databases using the Pediatric Health Information System (PHIS), a comparative financial and clinical administrative database maintained by a consortium of 28 children’s hospitals in the United States. From these eligible patients,
secondary diagnoses were printed and manually reviewed by all of the investigators. Patients were excluded from eligibility if they had comorbidities associated with immunodeficiencies, significant congenital heart disease, bronchopulmonary dysplasia, tracheomalacia, tracheostomy, whooping cough, diseases of the circulatory system, asthma, or alterations in consciousness. Patients requiring mechanical ventilation or other intensive therapies were also excluded. This data set was then compared with the bronchiolitis patients identified by the study coordinators during the 1998–1999 season to verify a match. This algorithm, thus, identified appropriate eligible patients. It was applied to electronic data from the PHIS system to identify historical control patients at the study hospitals for the same time period in the previous year (December 15, 1997, to March 31, 1998). A list of eligible patients was supplied to the study hospitals, and chart reviews were performed for prepost comparisons. Institutional review boards at each participating hospital concluded that, as long as patients were not randomized or identified in publications, consent would not be required.

Outcomes

The primary outcome of interest was the use of bronchodilator therapy. Secondary outcomes included the proportion of patients who received chest radiographs, testing for RSV, antibiotics, oxygen, or steroids, as well as the rates of hospital readmission and inpatient length of stay. Successful guideline implementation was defined in two ways: (1) the proportion of eligible infants placed on the guideline, and (2) the proportion of hospitals in which there was a 15% reduction of bronchodilator use. For the purpose of this study, guideline compliance was defined as a physician’s signature on the bronchiolitis hospital admission order sheet for patients who were designated as having bronchiolitis on hospital admission and otherwise met the criteria set for guideline eligibility.

Data Sources

Preimplementation and postimplementation data on hospital admissions, resource utilization ancillary to bed occupancy, and length of hospitalization were obtained from the PHIS database supplemented by data from administrative databases at each of the study hospitals. Details on the actual preimplementation and postimplementation frequency and type of bronchodilators used were obtained by manual chart reviews of the same patients.

Data on hospital characteristics were obtained from the National Association of Children’s Hospitals and Related Institutions database, and supplemented by an additional survey of each hospital completed by the principal investigator. Data obtained from these two sources included variables that characterized hospital size, managed-care penetration for children’s services in each of the hospitals, and organization of respiratory care. These data were supplemented by an additional survey completed by CHAI scientific directors at each site outlining additional characteristics relevant to implementation and care practices, such as the use of respiratory scores and prior bronchiolitis protocols.

Parent surveys were conducted by trained interviewers 7 days after discharge to determine satisfaction and timeline of recovery. Results of these analyses will be reported separately.

Sample Size

Sample size calculations were based on an estimated 15% reduction in the proportion of patients who would receive bronchodilator therapy (α = 0.05, power = 0.80). Preliminary estimates of bronchodilator use were drawn from the PHIS administrative database. Using the mean baseline estimate of bronchodilator use from the PHIS data, it was estimated that approximately 200 patients would be required. For intrahospital quality improvement activities, sample sizes were also calculated for individual hospitals based on their baseline bronchodilator use. These estimates varied between 150 patients and 700 patients. Some sites were not able to meet their individual requirement.

Data Analysis

χ² tests were used for analysis of categorical variables, and Student t tests were performed for normally distributed continuous variables. Wilcoxon rank sum tests were used for nonnormally distributed data. For the before and after analyses, the data were stratified categorically based on whether or not they represented information about care delivered before or after implementation of the guideline. Because the count of albuterol doses did not have a normal distribution, a Poisson regression model was constructed. The model examined the variation in albuterol use and the impact of the guideline in the five study hospitals after adjusting for patient age. The primary outcome of interest was the mean number of albuterol units used per patient. The key independent variable to be tested was whether the period was preguideline or postguideline. All statistical analyses were performed using PC-SAS software (release 8.1; SAS Institute; Cary, NC).

Results

Patient Characteristics

Complete data were available from seven of the original 11 hospitals, comprising 846 historical control patients and 793 patients seen after guideline implementation. During the preimplementation period, the mean age at hospital admission was 4.2 months. This decreased to 3.9 months in the postimplementation period (p < 0.01). Fifty-one percent of the control patients had Medicaid coverage or were self-paying. In the postimplementation period, 45% of the patients were Medicaid/self-paying (p = 0.04). A guideline hospital admission order was signed for 78% of all eligible infants during the study period (Table 1). This ranged from 46% at Site A to 96% at Site D.

Length of Stay

The mean (± SD) length of stay for bronchiolitis patients admitted to study hospitals during the baseline period, before the guideline was implemented, was 2.8 ± 1.9 days (Table 3). The mean length of stay for bronchiolitis patients in the period after the guideline was implemented was 2.6 ± 2.0 days, a decrease of 7% (p = 0.02). Length of stay decreased by 15% at site B (p = 0.02) and by 27% at site G (p = 0.0003).

Resource Use

Before the guideline was implemented, 81% of infants with a diagnosis of bronchiolitis received at least one nebulizer treatment (Table 4). This decreased to
74% after the guideline was implemented, a fall of 9% (p < 0.001). The proportion of patients who received steroids decreased by 44%, from 16% of patients in the control period to 9% after the guideline was implemented (p < 0.0001). Oxygen use, antibiotic use, radiologic studies, and blood gas testing all showed statistically insignificant decreases after implementation of the guideline. The proportion of patients who received nasopharyngeal washes to test for RSV antigen increased slightly after guideline implementation.

**Hospital Readmissions**

Data on hospital readmission within 7 days of discharge were available from six of the study hospitals. The mean hospital readmission rate within 7 days of discharge during the baseline period, before the guideline was implemented, was 1.7% (Table 4). The mean hospital readmission rate within 7 days of discharge after the guideline was implemented was 1.9% (p = 0.84). Hospital readmission within 7 days of discharge did not change significantly for any individual study site.

**Types of Bronchodilators Used**

The proportion of all eligible bronchiolitis patients who received any bronchodilator administration (84%) did not change after guideline implementation. Albuterol was the bronchodilator administered most often. During the preimplementation period, 80% of all patients received at least one dose of albuterol. This decreased slightly to 75% of all patients after the guideline was in place (p < 0.03). The proportion of all patients who received any ipratropium also fell after guideline implementation, decreasing from 17 to 0.2% (p < 0.0001). In contrast, the proportion of all patients who received at least one dose of racemic epinephrine increased significantly after guideline implementation, from 13% in the historical period to 34% after the guideline was introduced (p < 0.0001).

**Frequency and Intensity of Bronchodilator Treatment**

For all patients, the mean number of doses of bronchodilators received (Fig 1) decreased significantly (p < 0.0001) after introduction of the guideline, from 11.3 ± 13.7 doses (median, 8 doses) to 6.1 ± 8.8 doses (median, 3 doses). When considering only patients who received bronchodilators, the mean number of doses decreased (p < 0.0001) from 13.6 ± 14.0 doses (median, 11 doses) to 7.3 ± 9.1 doses (median, 4 doses). Similar effects were seen when albuterol use was studied. Before implemen-

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### Table 3—Length of Stay

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preguideline (Median/Mode)</th>
<th>Postguideline (Median/Mode)</th>
<th>Change From Baseline, %</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A</td>
<td>2.6 ± 1.6 (2/2)</td>
<td>2.7 ± 1.3 (2/2)</td>
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<tr>
<td>Site B</td>
<td>2.6 ± 1.6 (2/2)</td>
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<td>− 15</td>
<td>0.02</td>
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<tr>
<td>Site C</td>
<td>3.6 ± 2.2 (3/2)</td>
<td>3.5 ± 3.1 (3/2)</td>
<td>− 3</td>
<td>0.16</td>
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<tr>
<td>Site D</td>
<td>3.3 ± 2.3 (2/2)</td>
<td>3.9 ± 2.3 (3/2)</td>
<td>+ 18</td>
<td>0.05</td>
</tr>
<tr>
<td>Site E</td>
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<td>2.2 ± 1.5 (2/2)</td>
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<td>0.09</td>
</tr>
<tr>
<td>Site F</td>
<td>3.0 ± 2.3 (2/2)</td>
<td>3.1 ± 2.2 (2/2)</td>
<td>+ 3</td>
<td>0.74</td>
</tr>
<tr>
<td>Site G</td>
<td>3.0 ± 1.9 (2/2)</td>
<td>2.2 ± 1.7 (2/1)</td>
<td>− 27</td>
<td>0.0003</td>
</tr>
<tr>
<td>Overall</td>
<td>2.8 ± 1.9 (2/2)</td>
<td>2.6 ± 2.0 (2/2)</td>
<td>− 7</td>
<td>0.02</td>
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### Table 4—Resource Use*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preguideline</th>
<th>Postguideline</th>
<th>Change From Baseline, %</th>
<th>p Value</th>
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<td>793</td>
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<td>Nebulizer use</td>
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<tr>
<td>Steroid use</td>
<td>16</td>
<td>9</td>
<td>- 44</td>
<td>&lt; 0.0001</td>
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<tr>
<td>Oxygen use</td>
<td>47</td>
<td>45</td>
<td>- 6</td>
<td>0.30</td>
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<tr>
<td>Antibiotic use</td>
<td>50</td>
<td>47</td>
<td>- 6</td>
<td>0.30</td>
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<tr>
<td>Chest radiographs</td>
<td>68</td>
<td>65</td>
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<tr>
<td>Blood gas analysis</td>
<td>9</td>
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<td>RSV testing</td>
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<td>53</td>
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<td>Readmission to hospital within 7 days of discharge†</td>
<td>1.7</td>
<td>1.9</td>
<td>+ 12</td>
<td>0.84</td>
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*Data are presented as % unless otherwise indicated.
†Data are available from six sites only.
tation of the guideline, patients with a diagnosis of bronchiolitis received a mean of 10.3 ± 11.7 doses of albuterol (median, 8 doses). This fell to 4.8 ± 7.3 doses (median, 2 doses) after the guideline was in place (p < 0.0001). For those patients who received albuterol, the mean number of doses decreased (p < 0.0001) from 12.8 ± 11.8 doses (median, 11 doses) to 6.4 ± 7.8 doses (median, 3 doses). Similar changes were seen in ipratropium frequency.

Although the decrease in the proportion of patients receiving any albuterol was modest after guideline implementation, there was a statistically significant decrease in the number of doses of albuterol per patient (Fig 1). In the historical period, 73% of eligible bronchiolitis patients received more than two doses of albuterol. After the guideline was in place, 54% of eligible patients received more than two doses, a decrease of 26% (p < 0.0001). Before implementation, 66% of patients received more than four doses. This decreased by almost 50%, to 35% of patients after the guideline was in place (p < 0.0001).

**Hospital Characteristics**

The seven study hospitals varied in their structural characteristics (Table 5). The number of beds per hospital ranged from 90 to 299. Health maintenance organization penetration ranged from 15 to 38%. Five of the seven hospitals had a prior bronchiolitis protocol, and four of seven hospitals were using a respiratory scoring system before beginning the study. Respiratory care activity was integrated with nursing in six hospitals. Only one hospital had an automated physician order entry system in place.

**Poisson Analysis**

The adjusted mean albuterol use for each study site before and after introduction of the guideline is

**Table 5—Hospital Characteristics**

<table>
<thead>
<tr>
<th>Site</th>
<th>Beds, No.</th>
<th>Automated Physician Order Entry</th>
<th>Prior Bronchiolitis Protocol</th>
<th>Prior Systematic Scoring</th>
<th>Respiratory Care/Nursing</th>
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<td>B</td>
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<td>No</td>
<td>33</td>
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<tr>
<td>D</td>
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<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<td>E</td>
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<td>No</td>
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<td>26</td>
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</table>

**Figure 1. Frequency and intensity of bronchodilator treatments.**
shown in Table 6. Baseline albuterol use ranged from a low of 4.2 mean doses per patient at site B to 14.8 mean doses per patient at site E. After guideline implementation, the mean doses of albuterol per patient had decreased significantly (range, 2.1 to 8.0 mean doses per patient). Albuterol use over all five sites, adjusting for patient age, was reduced to 45% of the mean baseline level \((p < 0.0001)\). The impact of the guideline varied among sites and was greatest at site D, where the fall in albuterol use was fourfold. The ratio of mean doses of albuterol per patient at baseline to that after guideline implementation was 4.5. The effect was smallest at site A (ratio = 1.69).

### Discussion

We have reported here the results of a national demonstration project to extend the implementation of a successful evidence-based clinical practice guideline from one hospital to seven hospitals. This pilot project was designed to accomplish rapid implementation, data collection, and analysis within a multi-site network. In addition, we hoped to identify factors that contribute to successful implementation of a guideline.

Within just a single bronchiolitis season, some noteworthy changes in practice were seen. Length of stay decreased significantly. Although the proportion of eligible patients who received any bronchodilator did not change, use of albuterol, the most commonly used bronchodilator, decreased significantly after guideline implementation. In the addition, the mean number of doses of albuterol and all bronchodilators administered decreased significantly. The use of other resources decreased modestly.

In the last few years, numerous practice guidelines have been created and disseminated in the hope that physicians will adopt and adhere to their clinical recommendations. Although there have been some successes, there is abundant literature suggesting that many physicians are unaware of the guidelines or, at least, uninfluenced by them.\(^41–44\) Thus, simple dissemination of evidence-based guidelines has not been effective in changing behavior in daily practice.\(^45–49\)

In their awareness-to-adherence model, Pathman et al.\(^50\) suggested that physician adherence to clinical guidelines occurs through a series of sequential cognitive steps. First, physicians need to be aware of a guideline and understand its recommendations. Physicians then need to be convinced that the recommendations are sound. Finally, they may require help in adhering to the guideline once they decide to adopt it. For each physician, progression along the path to adherence can stop at any step for a variety of reasons.

Our success with this project may have been due to our attempt to meet the physicians’ needs at each of these steps. Because local control and “buy-in” have been shown to be important for successful implementation,\(^51\) each participating institution was encouraged to make minor modifications to the guideline, pathway, and order sheet as necessary to meet specific institutional requirements. When beginning this project, we were aware of studies\(^52–53\) suggesting that some physicians believe that guidelines are too cumbersome and time-consuming. Because our primary interest was the use of bronchodilator therapy, we concentrated on that outcome. Although physicians were encouraged to adopt all of the guideline recommendations, emphasis was placed on reducing bronchodilator use.

Each study hospital chose the educational strategies best suited to disseminate information about the guideline among physicians and hospital staff. These included presentations at medical grand rounds, meetings of community primary care physicians, house staff training sessions, nursing training forums, poster displays, and hospital news publications. To provide adherence support on a daily basis, we encouraged that a study coordinator attend daily rounds to track eligible patients, reinforce guideline principles, and resolve any problems inhibiting guideline implementation.

While we observed significant reductions in bronchodilator use after implementation of the guideline, wide variations in care persisted among the study centers despite the guideline. The dissimilarity observed may be a result of unequal experience with evidence-based medicine among the study hospitals. Alternatively, there may have been differences in the openness of each site to a change in practice, the strength of and respect for the local physician champion, or the support of each hospital’s chief executive officer. While each site was encouraged to adopt multiple standardized strategies to educate their attending physicians, residents, nurses, and respira-

<table>
<thead>
<tr>
<th>Site</th>
<th>Baseline Albuterol Use</th>
<th>Guideline Albuterol Use</th>
<th>Ratio, Baseline/Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11.7</td>
<td>7.5</td>
<td>1.56</td>
</tr>
<tr>
<td>B</td>
<td>4.2</td>
<td>2.1</td>
<td>2.0</td>
</tr>
<tr>
<td>C</td>
<td>12.1</td>
<td>5.7</td>
<td>2.12</td>
</tr>
<tr>
<td>D</td>
<td>13.2</td>
<td>3.1</td>
<td>4.26</td>
</tr>
<tr>
<td>E</td>
<td>14.8</td>
<td>8.0</td>
<td>1.85</td>
</tr>
</tbody>
</table>
ory therapists, compliance varied between the study hospitals. The recent publication by Lichtman et al.\(^4\) identified similar experiences in multisite adaptation of a practice guideline. In their study, the presence of an integrated clinical implementation team was believed to be an important factor for promoting guideline use.

Although a hierarchical model would have been ideal for comparing hospital-level characteristics on guideline impact while adjusting for patient characteristics, we were unable to do this because of a paucity of information on individual characteristics and the small number of study sites. Therefore, the regression model allows us only to comment on site-specific impact without identifying which specific site characteristics were responsible for the change. Ultimately, understanding the impact of these underlying system factors may be critical to the promotion of evidence-based bronchodilator use.

It is important to note that the medical literature contains evidence both for and against the use of bronchodilators for bronchiolitis. One meta-analysis\(^5\) concluded that bronchodilators produce modest short-term improvement in the clinical features of mild or moderately severe bronchiolitis, whereas another study\(^6\) concluded that short-term \(\beta_2\)-agonist therapy had no impact on the hospitalization rate or respiratory rate of patients. In addition, there have been randomized trials\(^7\)–\(^8\),\(^11\),\(^56\)–\(^63\) both supporting and refuting the benefit of bronchodilators. The team of clinicians who developed this guideline was aware of the conflicting evidence, and the recommendations represent their best judgment of the interpretation of that evidence. Thus, the focus of the guideline was not on avoidance of all bronchodilators, but rather on the reduction in indiscriminate and repeated use of bronchodilator therapies when there is no demonstrable benefit. This recommendation and its acceptance are reflected in the fact that the proportion of all eligible bronchiolitis patients who received any bronchodilator administration did not change after guideline implementation. However, the mean number of doses received decreased significantly.

In summary, the multisite CHAI collaborative study appears to be a promising laboratory for large-scale quality improvement initiatives. Despite differences in experience with evidence-based medicine and variations in insurance status and racial and ethnic makeup of the populations served, this select group of large children’s hospitals was successful in demonstrating guideline implementation for the complicated condition of bronchiolitis. Clearly, however, changing all embedded clinical care patterns will take longer than a single season. More significant changes in practice are expected as the project continues as demonstrated by the sustained results observed with the multiyear use of this guideline at the site where it was developed.\(^24\) In addition, future collaborative projects are planned to promote clinical practices that lead to improved health outcomes for children.

**References**
