Inpatient Bronchiolitis Guideline Implementation and Resource Utilization

abstract

BACKGROUND: Provider-dependent practice variation in children hospitalized with bronchiolitis is not uncommon. Clinical practice guidelines (CPGs) can streamline practice and reduce utilization however, CPG implementation is complex.

METHODS: A multidisciplinary team developed and implemented CPGs for management of bronchiolitis for children <2 years old. Children with comorbidities, ICU admissions, and outside hospital transfers were excluded. Implementation involved teamwork and collaboration, provider education, online access to CPGs, order sets, data sharing, and monthly team meetings. Resource utilization was defined as use of chest x-rays (CXRs), antibiotics, steroids, and more than 2 doses of inhaled bronchodilator use. Outcome metrics included length of stay (LOS) and readmission rate. Bronchiolitis season was defined as September to April. Data were collected for 2 seasons post implementation.

RESULTS: The number CPG-eligible patients in the pre- and 2 postimplementation periods were similar (1244, preimplementation; 1159, postimplementation season 1; 1283 postimplementation season 2). CXRs decreased from 59.7% to 45.1% (P < .0001) in season 1 to 39% (P < .0001) in season 2. Bronchodilator use decreased from 27% to 20% (P < .01) in season 1 to 14% (P < .002) in season 2. Steroid use significantly reduced from 19% to 11% (P < .01). Antibiotic use did not change significantly (P = .16). LOS decreased from 2.3 to 1.8 days (P < .0001) in season 1 and 1.9 days (P < .05) in season 2. All-cause 7-day readmission rate did not change (P = .45).

CONCLUSIONS: Bronchiolitis CPG implementation resulted in reduced use of CXRs, bronchodilators, steroids, and LOS without affecting 7-day all-cause readmissions. *Pediatrics* 2014;133:e730–e737

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ABBREVIATIONS CMC—Children’s Medical Center Dallas CPG—clinical practice guidelines CXR—chest x-ray ED—emergency department LOS—length of stay MOC—maintenance of certification

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Bronchiolitis is a common cause of pediatric hospitalization. Variation in the use of tests and treatments for management of bronchiolitis exists, some of which may contribute to increased health care costs that are estimated to be $545 million annual total direct expenditure nationally. In 2006, the American Academy of Pediatrics published a national clinical practice guideline (CPG) for management of children with bronchiolitis. The CPG does not recommend routine tests and treatments, emphasizing a diagnosis of bronchiolitis based on history and physical examination, and supportive management. Nevertheless, nationally, there is a wide variation in use of tests and treatments in the management of bronchiolitis.

CPGs can be a powerful resource to reduce variation and help providers deliver disease-specific best practice. Therefore, many national organizations support development of CPGs. Integrating a CPG into practice requires changes in physician behaviors and remains a significant challenge.

Studies suggest that locally developed CPGs affect patient outcomes more than those developed nationally. At Children's Medical Center (CMC) Dallas, we noted variation in practice for children hospitalized with a diagnosis of bronchiolitis and identified gaps between practice and evidence. As a result, we developed a CPG for bronchiolitis. The goal of CPG implementation was to reduce resource use and improve outcomes. Based on review of our internal data and data available in the literature, we identified opportunities to reduce use in the management of children with bronchiolitis. Our primary aim was to reduce use of chest x-rays (CXR), bronchodilators, steroids, and antibiotics. Our secondary aim was to reduce length of stay (LOS) without affecting the readmission rate.

METHODS

Setting

CMC is a tertiary care hospital affiliated with the University of Texas Southwestern Medical Center with 422 inpatient beds. Annually, bronchiolitis accounts for >3000 emergency department (ED) visits, resulting in >1100 admissions. ED and inpatient services together are serviced by >60 physicians, 150 trainees, and >350 nurses, respiratory therapists, and advance practice practitioners. Inpatient services include both teaching and nonteaching services. The project was approved by institutional review board at University of Texas Southwestern Medical Center and Children's Medical Center, Dallas.

Intervention

Development of an Institutional CPG Through Teamwork and Collaboration

A multidisciplinary team of key stakeholders formed the Bronchiolitis Task Force in November 2010 with the aim of developing and implementing evidence- and consensus-based bronchiolitis CPG for hospitalized children from birth to <2 years of age without an underlying comorbid condition. The team included nurses, respiratory therapists, and physicians from the ED; hospitalists; general pediatricians; and infectious disease, pulmonologist, and critical care medicine subspecialties. The team reviewed current institutional practices, national and other children's hospitals' CPGs, identifying gaps between practice and evidence, including areas of variation, and potential areas for improvement. A literature review was conducted and evidence was graded. Consensus was used where evidence was lacking. Institutional bronchiolitis CPGs were developed with 10 recommendations (Table 1).

CPG Implementation Interventions

Key drivers for implementation involved education of providers, integration of recommendations into electronic order sets, easy online accessibility of CPG, use of objective measures such as a bronchiolitis scoring tool, regular data sharing with providers, and monthly team meetings to evaluate and troubleshoot implementation interventions (Table 2). Electronic order sets and clinical decision support were used to facilitate effective implementation of specific CPG recommendations. A checkbox in the electronic order set was used as a common communication tool among providers to identify children on CPGs. Providers were educated directly through lectures, e-mails, and distribution of laminated pocket-sized copies with key CPG recommendations. Computer screen savers were used to remind providers of the CPG. Outcome metrics and data were shared with providers before implementation and at regular intervals during implementation. The CPG was developed from November 2010 to May 2011 and approved and implemented in September 2011.

TABLE 1 Guideline Recommendations

1. Nasal suction via bulb or neosucker is recommended to clear the upper airway.
2. Deep suction (beyond the nasopharynx) is not recommended and requires a special order.
3. Oxygen is recommended for hypoxia, defined as a persistent oxygen saturation (SpO2) <90%.
4. SpO2 spot checks are recommended to monitor for hypoxia.
5. Continuous SpO2 monitoring is suggested for monitoring patients on oxygen.
6. Continuous cardiopulmonary monitoring (CAM) is recommended for patients at high risk of apnea. It is recommended that CAM be discontinued if there are no apneas for 24 h.
7. Bronchodilators should not be used routinely in the management of bronchiolitis. A single trial of inhaled epinephrine or albuterol for respiratory distress may be considered, but only if h/o asthma, atopy, or allergy. It is recommended to discontinue inhalation therapy if there is no clinical response.
8. Steroids, antibiotics, nasal decongestants, and chest physiotherapy are not recommended.
9. Diagnostic studies (CXR, complete blood count, C-reactive protein, and blood cultures) are not routinely indicated.
10. Standard isolation (contact or droplet precautions) are recommended for all patients.
TABLE 2 Key Drivers of Interventions Used to Achieve the Desired Aim

<table>
<thead>
<tr>
<th>Key Drivers</th>
<th>Interventions</th>
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<tbody>
<tr>
<td>Teamwork and collaboration</td>
<td>• Established and sustained a bronchiolitis task force of key stakeholders at the beginning of CPG development.</td>
</tr>
<tr>
<td></td>
<td>• Developed CPG recommendations through evidence and consensus.</td>
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<td></td>
<td>• Individual departments vetted CPG recommendations and interventions through members of task force.</td>
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<td></td>
<td>• Brainstorming in monthly team meetings to improve implementation.</td>
</tr>
<tr>
<td>Education of providers</td>
<td>• Involved all nurses, respiratory therapists, physicians, and trainees.</td>
</tr>
<tr>
<td></td>
<td>• Used multiple educational formats to maximize provider education.</td>
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<tr>
<td></td>
<td>• Used reminder systems of screen savers and inpatient rounds to promote use of CPG.</td>
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<tr>
<td>Easy online access of CPG</td>
<td>• Created hospital intranet Web site for easy availability of CPGs.</td>
</tr>
<tr>
<td></td>
<td>• Used common Web site for dissemination of educational material for teaching families of patients and providers.</td>
</tr>
<tr>
<td></td>
<td>• Disseminated MOC Part 4 information about the project, including dates for team meetings.</td>
</tr>
<tr>
<td>Use of electronic order sets</td>
<td>• Automated CPG-recommended electronic order sets.</td>
</tr>
<tr>
<td></td>
<td>• Used order set as a communication tool between providers.</td>
</tr>
<tr>
<td></td>
<td>• A prechecked box in the order sets identified patients on CPGs.</td>
</tr>
<tr>
<td>Objective measures for some CPG recommendations</td>
<td>• Used a bronchiolitis scoring tool to measure response to bronchodilators.</td>
</tr>
<tr>
<td></td>
<td>• Respiratory therapists documented pre-post scores in the electronic medical record.</td>
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<tr>
<td></td>
<td>• Developed criteria for admission, escalation of care, transfer to ICU and discharge.</td>
</tr>
<tr>
<td></td>
<td>• Defined hypoxia as room air saturation ≤90%.</td>
</tr>
<tr>
<td></td>
<td>• Developed clear monitoring recommendations for patients on and off oxygen therapy.</td>
</tr>
<tr>
<td>Data staring with providers</td>
<td>• Regularly shared pre-post implementation data with providers for transparency and engagement.</td>
</tr>
<tr>
<td>Monthly team meetings during bronchiolitis season</td>
<td>• Monthly task force team meetings held during implementation to review CPG data, identify barriers, and improve implementation through team discussions and brainstorming.</td>
</tr>
</tbody>
</table>

Before our project, there was no institutional bronchiolitis CPG. A bronchiolitis order set was in place for 2 years before CPG implementation; however, the old order set did not integrate key recommendations, such as hypoxia limits, use of spot pulse oximeter, or bronchiolitis score.

Study Population

The CPG-eligible population was defined as all previously healthy children from birth to <2 years old with a primary diagnosis (International Classification of Diseases Ninth Revision: 466.11 and 466.19) of bronchiolitis or a secondary diagnosis of bronchiolitis with 1 of the primary diagnoses being dehydration, viral pneumonia, acute upper respiratory infection, urinary tract infection, respiratory failure, asthma, or pneumonia organism unspecified. For data analysis, all patients with comorbidities and those requiring critical care were excluded. Children transferred from outside facilities were excluded because of lack of pretransfer data.

Methods of Evaluation

Study Design and Duration

This study was a classic before and after intervention design. For the purpose of data analysis, bronchiolitis season was defined as September 1 to April 30 of the succeeding year. Preimplementation period was from September 2010 to April 2011. September 2011 to April 2012 was defined as the postimplementation season 1 and September 2012 to April 2013 was defined as postimplementation season 2.

Data Source

Hospital administrative records were reviewed. Information technology–trained analysts collected data and ensured data quality and adequacy by repeating measurements and data extraction.

Data Metrics

Specific, Measurable, Aggressive yet Attainable, Result-oriented and Time-bound metrics were identified and defined for data extraction (Table 3). These metrics were selected because they drive use and outcomes the most. The percentage of children who had a CXR, any antibiotic or steroid (oral, intravenous, or intramuscular), and >2 doses of inhaled bronchodilators (albuterol, levalbuterol, or epinephrine) were the defined utilization metrics. A small percentage of CPG-eligible children with bronchiolitis may respond to bronchodilators; therefore, >2 doses of inhaled bronchodilator use was chosen as the utilization metric. A modified Respiratory Distress Assessment Index was used to evaluate response to bronchodilators. Respiratory therapists documented before and after scores on all patients requiring any bronchodilator therapy. Bronchodilators were discontinued on patients with no significant improvement in scores.

Length of stay (LOS) and all-cause 7-day readmission rate were defined as outcome metrics (Table 3). The case-mix index was calculated for each season. The case-mix index reflects the diversity, clinical complexity, and resource needs of a patient population in the hospital. Other CPG implementation measures included use of bronchiolitis order sets for CPG-eligible patients, use of chest physiotherapy, defining hypoxia, and use of spot pulse oximetry for monitoring for hypoxia. Before CPG implementation, hypoxia definition was attending dependent. During CPG implementation, hypoxia was defined as persistent saturation <90%. Before CPG implementation, spot pulse oximeter use was not a practice and monitoring practices were attending dependent. During CPG implementation, monitoring practices
TABLE 3  Data Definitions for CPG-Eligible Patients

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Metric Definition</th>
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<tbody>
<tr>
<td>CXR rate</td>
<td>Percentage of patients with any CXR</td>
</tr>
<tr>
<td>Inhalation rate (&gt;2 dose)</td>
<td>Percentage of patients who received more than 2 doses of bronchodilators*</td>
</tr>
<tr>
<td>Antibiotics rate</td>
<td>Percentage of patients who received any oral, IV, or IM antibiotic</td>
</tr>
<tr>
<td>Steroid rate</td>
<td>Percentage of patients who received any oral, IV, or IM steroids</td>
</tr>
<tr>
<td>LOS, d</td>
<td>Time from arrival at CMC to discharge time</td>
</tr>
<tr>
<td>Readmission rate within 7 d</td>
<td>Number of all-cause readmissions to ward or ICU within 7 d</td>
</tr>
</tbody>
</table>

IM, intramuscular; N, intravenous.

* Albuterol, xopenex, epinephrine, or atrovent.

were streamlined and incorporated in the order sets (Table 1). Spot pulse oximeter use was measured as any CPG-eligible patient with a spot pulse oximeter order during hospitalization.

Monthly meetings were held to review run charts and discuss effect of implementation and plan Plan-Do-Study-Act (PDSA) cycles. The key changes involved data sharing and improving provider education on CPG recommendations.

Data Analysis

Data were collected via the electronic medical record (Epic, Inc, Madison, WI), tabulated by using Excel (Microsoft, Inc, Redmond, WA) and analyzed (IBM SPSS Statistics, IBM Corporation, Armonk, NY). Pre- and postimplementation data were compared by using standard t test and P values were calculated with P < .05 being significant. Preimplementation utilization and outcome metrics were compared with season 1 and season 2. All data were plotted in the run chart format to study trends.

RESULTS

CXR Use

CXR use was reduced from 59.7% (742 of 1244 children) in the preimplementation season to 45.1% (523 of 1159 children; P < .0001) in season 1 and 39% (485 of 1283 children; P < .0001) in season 2 (Table 4). Monthly run charts show a consistently sustained downward trend (Fig 1).

Bronchodilator Use

Bronchodilator use in the preimplementation period decreased from 27% (256 of 1244 children) to 20% (165 of 1159 children; P < .01) in season 1 and 14% (165 of 1283 children; P < .0002) in season 2. Trends in monthly run charts indicate that bronchodilator use was highest early in the season. The reduction in bronchodilator usage was consistently sustained with a downward trend (Fig 2).

Steroid Use

Steroid use was not affected during season 1. Steroid use significantly declined after season 2 (236 of 1244 children versus 141 of 1283 children; P < .01) (Table 4).

Antibiotic Use

Antibiotic use reduced from 37% to 35% (P = .39) in season 1, and then to 25% (P = .16) in season 2 (Fig 3).

LOS

The average LOS decreased from 2.3 days to 1.8 days (P < .0001) in season 1 with no significant change in all-cause 7-day readmission rates (2.3% vs 1.8%; P = .45). The LOS of <2 days was sustained in season 2 (P < .03).

Other Measures

Chest physiotherapy rate was reduced by 50% in season 1 (12% use to 6%). The use of spot pulse-oximetry for monitoring for hypoxia increased from 0% in the preimplementation period to 76% in season 1. The ICU admission rate was not significantly affected. These measures were sustained in season 2. Bronchiolitis order sets were used in 75% of CPG-eligible patients in season 1 and 78% of the CPG-eligible patients in season 2.

DISCUSSION

We describe a bronchiolitis CPG implementation intervention that resulted in reduced use of CXRs, bronchodilators, steroids, and LOS within a year after implementation. These outcomes were sustained in the second year. The intervention did not reduce the use of antibiotics.

Impact of bronchiolitis CPG implementation has been studied for more than a decade and most studies have shown some reduction in use and LOS.6,13–19 These studies show a reduction in CXR use from 70% to 56%,6,13,14 any bronchodilator usage from 69% to 48%,6,15–16 steroid use from 48% to 16%,6 antibiotic use from 57% to 50%,6,13–16 and reduction in LOS from 2.9 days to 2.4 days.6,13–16 Through our project, we were able to achieve greater reductions in use and LOS than previously reported and these reductions were sustainable over the next year. National CPGs might have affected our low preimplementation baseline utilization and LOS. However, we were able to move our baseline farther down significantly. It is difficult to compare across institutions and identify the specific implementation factors that led to our reduced utilization and outcomes. We used multiple interventions to improve provider buy-in and use of the CPGs, and believe that these interventions together helped achieve our goals.

CPG Implementation Involves Multifaceted Approach

CPG implementation is complex and no single implementation method is superior. Frontline provider buy-in remains a challenge to successful implementation.10,20 Dissemination and diffusion of innovation in any organization and change in provider behaviors might be achieved through a multifaceted approach.20,21 We used a combination of implementation interventions to implement CPG.
These interventions are described in the following paragraphs.

**Teamwork and Collaboration**

Involving key stakeholders early on during CPG development and continuing engagement throughout implementation was a key element in our implementation. Team-based care is central to improving health care. As innovative models of care are developed, emphasis is being focused to encouraging physicians, nurses, and other health care providers to collaborate better and coordinate care as a team. Our interventions led to improved collaboration and teamwork between different disciplines. This was achieved by involving key stakeholders in the initial CPG development and keeping them engaged throughout implementation. Members of bronchiolitis task force became the “go-to” people for their departments. Monthly team meetings were held to discuss barriers, identify potential solutions, review and share data, and recognize early successes with the providers.

**Education and Accessibility of CPGs**

Provider buy-in on CPGs involves knowledge, acceptance of CPG recommendations, and behavior changes that reflect acceptance. Multiple approaches to change physician behaviors to adopt evidence-based practices have been described and education remains important. Our implementation involved education of all nurses, respiratory therapists, and physicians, including trainees using multiple educational formats. The CPG document provided academic details, including sources of evidence supporting specific recommendations. Additionally, CPGs were made available on the hospital intranet for easy online accessibility.

### Table 4: Outcomes of Pre- and Post CPG Implementation

<table>
<thead>
<tr>
<th>Metric</th>
<th>Preimplementation (September 2010–April 2011)</th>
<th>Postimplementation (September 2011–April 2012)</th>
<th>Postimplementation (September 2012–April 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume, CPG eligible</td>
<td>1244</td>
<td>1159 (NS)</td>
<td>1283 (NS)</td>
</tr>
<tr>
<td>Mean LOS, d</td>
<td>2.25</td>
<td>1.7 (.001)*</td>
<td>1.9 (.03)*</td>
</tr>
<tr>
<td>Readmission rates, %</td>
<td>2.3</td>
<td>1.8 (.45)</td>
<td>1.8(.45)</td>
</tr>
<tr>
<td>CXR rate, %</td>
<td>59.65</td>
<td>45.1 (.001)*</td>
<td>39.0 (.001)*</td>
</tr>
<tr>
<td>Bronchodilator rate (&gt;2 doses), %</td>
<td>27</td>
<td>20 (.01)*</td>
<td>14 (.002)*</td>
</tr>
<tr>
<td>Antibiotic rate, %</td>
<td>37.06</td>
<td>35.2 (.59)</td>
<td>25.0 (.16)</td>
</tr>
<tr>
<td>Steroid rate, %</td>
<td>19.0</td>
<td>19.75 (.71)</td>
<td>11.25 (.018)*</td>
</tr>
</tbody>
</table>

*a* Statistical significance is determined by t-test. Season 1 was compared with preimplementation data.

*b* Season 2 data were compared with preimplementation data.

*c* Volume is the total number of CPG-eligible patients hospitalized for management of bronchiolitis. Volume includes all inpatient and observation CPG-eligible patients.

*d* Seven-day readmission rates are for all admissions from inpatient and observation.

**Figure 1**

A control chart shows a sustained reduction in CXR use between pre- and postimplementation periods in the CPG-eligible patients. The bar represents the average CXR use during each season.
Use of Bronchiolitis Order Sets

CPG recommendations were incorporated in the bronchiolitis order sets that were designed to improve workflow and to ensure provider autonomy to order outside of CPG recommendations, if required.

Objective Measures for Specific Recommendations

Bronchodilator Use

Overuse of bronchodilators in the management of bronchiolitis remains a challenge. A recent study of 17 non-free-standing children’s and urban hospitals reported a reduction in any bronchodilator use from 70% to 58%, with reduction in average dose per patient to 4.3 from 7.4. Bronchodilator use significantly decreased from 27% to 20% within a year of
implementation during our project, and subsequently decreased to 14% in the second season. Factors that may have contributed to this include (1) use of a score-based protocol to trial bronchodilators; (2) streamlining criteria for starting, continuing, and stopping bronchodilators; and (3) incorporating the protocol in the electronic order sets and documentation of trial results. There is a lack of available quality metrics for bronchodilator use in children with bronchiolitis. We believe that using >2 doses of bronchodilators as an outcome metric helped secure physician buy-in, as it allowed physicians to trial and measure response to bronchodilators, then continue or discontinue bronchodilator use based on the response to the trial. This preserved physician autonomy, which is crucial to CPG adoption by physicians.\textsuperscript{10,26}

CXR and Antibiotic Use
Provider responsiveness to the CPG in CXR use was higher than antibiotics. We were able to significantly reduce CXR use from 59% to 45% within a season and then to 39% in the subsequent season. Developing specific indications for CXR use, reviewing the previous season’s CXR results and their impact in clinical decision-making, and continuing implementation interventions are reasonable next steps to further reduce CXR rates without compromising quality and safety.

Antibiotic use did not decrease during CPG implementation. In children with bronchiolitis, antibiotics are recommended only if a secondary bacterial infection is suspected.\textsuperscript{2,8} We believe that this may be related to lack of objective data to denounce the presence of a bacterial super infection. Such objective measures are lacking, especially in the management of otitis media, which remains the most common reason for the use of antibiotics in young children with bronchiolitis.\textsuperscript{3}

Developing evidence- and consensus-based indications for use of antibiotics in healthy children with bronchiolitis, reviewing and sharing antibiotic-specific data with providers, integrating antibiotic stewardship, and reinforcing education are next steps to impact antibiotic use.

LOS
LOS was significantly reduced in season 1 and this result was sustained in season 2. This may be attributed to specific CPG recommendations, such as defining hypoxia limit, adopting aggressive oxygen-weaning protocols, and use of spot pulse-oximetry to monitor for hypoxia instead of continuous cardiorespiratory monitoring on all hospitalized children. These practice changes might have directly affected the LOS.

Administration and Leadership Support
Engaging senior leaders of nursing, respiratory care, physicians, and hospital administrators led to a shift in culture that supports evidence-based practice and provides resources to support the project, such as informatics and administrative resources. Division directors granted valuable time for provider participation. Individual team members then involved respective divisions to discuss CPG recommendations, review orders sets, and educate faculty and fellows. Support from senior leaders facilitated navigation through multiple complex systems within the hospital.

In September 2012, the project was approved for maintenance of certification (MOC) part 4 credits. Physicians participating in the project were eligible to receive MOC credits. It is possible that this may have improved physician participation.

Limitations
This project has several limitations. We used <2 years as the age limit for our cohort per the American Academy of Pediatrics guidelines; a more restricted age definition (<12 months) may have decreased overlap with viral-induced wheezing. We monitored for incorrect diagnosis and inappropriate use of CPGs and did not identify any significantly associated adverse effects of the bronchiolitis CPG. However, these effects may be present, just not yet appreciated. Bronchiolitis order sets were used in only 75% of CPG-eligible patients in season 1 and 78% in season 2. It is possible that those not using the order sets are still following CPG recommendations, but not using order sets. Conversely, it is possible that those using order sets may not follow certain CPG recommendations. Currently, we are unable to identify these effects. We did not measure the use of hypertonic saline (3%) and viral testing. Perhaps a trial of 3% hypertonic saline may be helpful to move physicians away from their use of $\beta$-agonist.

CONCLUSIONS
Implementing an institutional bronchiolitis CPG with multifaceted implementation strategies resulted in reduced use of CXRs, bronchodilators, and steroids, and improved outcomes, such as reduced LOS, with no change in all-cause 7-day readmissions. Antibiotic use was not affected by the CPG implementation. These results were obtained within 1 year of implementation and were sustained in the following year. Interventions used during this project included teamwork and collaboration, provider education, easy online accessibility of CPG, use of electronic order sets and objective measures like a bronchiolitis score for specific CPG-recommended interventions, data sharing, and monthly team meetings. Once adjusted to local context, we believe that these combined interventions might affect CPG implementation in other health care systems.
REFERENCES


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