A Cost-Effectiveness Analysis of Inhaled Corticosteroid Delivery for Children with Asthma in the Emergency Department

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Objective To determine the clinical effectiveness and cost-effectiveness of 3 inhaled corticosteroid (ICS) delivery options for children with asthma treated in and discharged from the emergency department (ED).

Study design We conducted cost-effectiveness analysis using a decision tree to compare 3 ED-based ICS delivery options: usual care (recommending outpatient follow-up), prescribe (uniformly prescribing ICS), and dispense (uniformly dispensing ICS). Accounting for expected follow-up rates, prescription filling, and medication compliance, we compared projected rates of ED relapse visits and hospitalizations within 1 month of ED visit across all 3 arms. Direct and indirect costs were compared.

Results The model predicts that the rate of return to ED per 100 patients within 1 month of the ED visit was 10.6 visits for the usual care arm, 9.4 visits for the prescription arm, and 8.4 visits for the medication-dispensing arm. Rates of hospitalization per 100 patients were 2.4, 2.2, and 1.9, respectively. Direct costs per 100 patients for each arm were $23,400, $20,800, and $19,100, respectively. Including indirect costs related to missed parental work, total costs per 100 patients were $27,100, $22,000, and $20,100, respectively. Total cost savings per 100 patients comparing the usual care arm with the medication dispensing arm was $7000.

Conclusions This decision analysis model suggests that uniform prescribing or dispensing of ICS at the time of ED visit for asthma may lead to a decreased number of ED visits and hospital admissions within 1 month of the sentinel ED visit and provides a substantial cost-savings. (J Pediatr 2012;161:903-7).

The incidence of acute care visits for asthma is increasing.1-3 Although controller medications reduce the frequency of asthma acute care visits, they continue to be underprescribed.4-9 Children with asthma seen in the emergency department (ED) are at high risk for future exacerbations, making it imperative that they receive appropriate preventive care.10 Traditionally, the delivery of preventive asthma care occurs in the outpatient setting. Unfortunately, rates of outpatient follow-up after ED visits for asthma exacerbations have been reported as suboptimal and, subsequently, a minority of patients receive inhaled corticosteroids (ICSs) after ED visits for asthma.11-13

The low rates of outpatient follow-up and ICS use after ED visits for asthma suggest a need to expand our model of delivering preventive care. One solution is to increase the rates of preventive care delivery in the acute care setting.4,7,14-16 Consistent with this, the Global Initiative for Asthma (GINA) 2008 guidelines recommend initiation or continuation of ICSs prior to discharge from the ED.17 However, the National Heart, Lung, and Blood Institute 2007 guidelines only recommend considering the initiation of an ICS upon ED discharge. There remains a lack of consensus among physicians who care for children in the ED setting regarding their role in the delivery of preventive care to asthmatics, including prescribing ICSs,4,18

The purpose of this study is to use decision analysis to compare 3 ED-based ICS delivery options for children with asthma—(1) usual care; recommend that patients follow-up with their primary care physician (PCP) to consider starting an ICS; (2) prescribe: ED personnel prescribe ICS to children with asthma in the ED; and (3) dispense: dispense ICS to children with asthma in the ED. In order to determine the effectiveness of each system, we compared expected rates of ED relapse visits and hospitalizations, as well as medical costs between each arm.

Methods

We constructed a decision tree to represent each of the 3 ICS delivery options (Figure 1; available at www.jpeds.com). Once the decision tree was created, we surveyed the literature to obtain data on the assumptions needed for the decision analysis (Table 1). Assumptions for this analysis included percentage of patients expected to attend follow-up appointments,19 percentage of patients expected to receive a prescription for ICS if they attended outpatient follow-up,20 rates of expected prescription filling,21 and expected
medication compliance. We also identified expected rates of relapse to the ED within 1 month of the sentinel event and then used a relative risk of (0.5) to calculate the risk of relapse for patients on ICS. Additionally, we included expected hospitalization rates for each relapse visit to the ED. After all the estimates were placed in the decision tree, a hypothetical cohort of 100 children with asthma being discharged from the ED was introduced into each arm of the tree. We then calculated ED relapse visit rates and subsequent hospitalizations in each tree.

Cost-Effectiveness Analysis
The purpose of the cost-effectiveness analysis was to evaluate the cost effectiveness or potential cost savings attributable to improved delivery of ICS in the "prescribe" and "dispense" arms of the study. The analysis including only direct costs related to health care utilization is from the perspective of the health system. Direct costs included cost of the ICS, cost of follow-up visit, cost of relapse ED visit, and cost of hospitalization. Unpublished analysis of 2010 South Carolina Medicaid data was used for controller medication cost. The average costs of fluticasone ($62), budesonide ($117), and beclomethasone ($82) were entered in the model. In the medication-dispensing arm of the study, a 40% discount was applied to the cost of the ICS to account for discounted hospital purchase prices. South Carolina Medicaid data were also used for the cost of asthma-related outpatient follow-up appointments, asthma-related ED visits, and asthma-related hospitalizations (all costs are given in 2010 US dollars; Table I).

In an extended analysis from the societal perspective, indirect costs related to missed parental work days were included. We first calculated expected missed school days and then translated those data into missed parental work days. For each outpatient visit, we assigned 0.5 day of missed school.

For each ED relapse visit, we assigned 1 day of missed school and then multiplied this by a factor of 0.5, accounting for half of the ED visits taking place after school hours, for a total of 0.5 missed school day. For hospital admissions, we used 2006 Health Care Cost and Utilization Project mean length of stay per asthma admission of 2.2 days, which translates into 3 days of missed school. We then used a ratio of missed school days-to-missed parental work days of 1:0.82, a factor taken from previously published parental reporting of missed school days and missed parental work days per year secondary to having a child with asthma. Using data from the Bureau of Labor Statistics, we then applied a median hourly wage of $15.95 to calculate indirect costs due to missed parental work per asthma visit. Total indirect costs per outpatient visit, ED visit, and hospital admission were $52.32, $52.32, and $319, respectively.

Sensitivity Analysis
We performed a sensitivity analysis to determine the stability of our model. We varied selected model assumptions thought to contribute most to our model by 20% bidirectionally. We varied the medication cost, hospital medication discount, ED visit cost, admission cost, ED relapse rate, and admission rate.

Results
Results of our decision model suggest that when compared with the usual care system of recommending outpatient follow-up, both the uniform-prescribing and the medication-dispensing options result in a decreased number of ED relapse visits and subsequent hospital admissions over the 1-month period following the sentinel ED visit. Additionally, we found that the usual care option was the most expensive ICS delivery option both when comparing direct medical costs alone and when including indirect costs in the analysis. In both analyses, the medication-dispensing system was the least expensive (Table II).

When comparing the medication-prescribing arm to usual care, results of sensitivity analysis show stability of our model, consistently predicting cost-savings (Figure 2, A). Medication cost had the most significant influence on the model’s cost-savings.

When comparing medication dispensing to usual care, results of sensitivity analysis show stability of our model, consistently predicting cost-savings (Figure 2, B). ED relapse rate and medication cost had the greatest influence on the model’s cost-savings.

We also calculated the total number of patients in each arm who ultimately end up with an ICS and the number of patients who end up compliant with ICS using published medication compliance rates. Of the 100 patients in the usual care arm, only 15 are projected to get an ICS, and only 7 are projected to be compliant with ICS after an ED visit for acute exacerbation. For the prescription arm, 59 of the 100 patients are projected to get an ICS, and 28 are projected to be compliant with ICS. For the medication-dispensing

### Table I. Key assumptions for the decision tree

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Model input</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow-up rate after ED visit for acute exacerbation</td>
<td>46%</td>
<td>Zorc et al^12</td>
</tr>
<tr>
<td>ICS prescription rate of patient attends follow-up</td>
<td>54%</td>
<td>Cabana et al^20</td>
</tr>
<tr>
<td>Prescription fill rate</td>
<td>59%</td>
<td>Wang et al^21</td>
</tr>
<tr>
<td>Medication compliance</td>
<td>48%</td>
<td>McQuaid et al^22</td>
</tr>
<tr>
<td>ED relapse rate</td>
<td>11%</td>
<td>Zorc et al^12</td>
</tr>
<tr>
<td>Relative risk of ED relapse if taking ICS</td>
<td>0.5</td>
<td>Sin and Marr^23</td>
</tr>
<tr>
<td>Hospital admission rate</td>
<td>23%</td>
<td>Pollack et al^24</td>
</tr>
<tr>
<td>ICS cost</td>
<td>$87*</td>
<td>South Carolina Medicaid Data</td>
</tr>
<tr>
<td>Hospital medication discount</td>
<td>40%</td>
<td>South Carolina Medicaid Data</td>
</tr>
<tr>
<td>Outpatient follow-up visit cost</td>
<td>$97</td>
<td>South Carolina Medicaid Data</td>
</tr>
<tr>
<td>ED visit cost</td>
<td>$237</td>
<td>South Carolina Medicaid Data</td>
</tr>
<tr>
<td>Hospital admission cost</td>
<td>$6192</td>
<td>South Carolina Medicaid Data</td>
</tr>
</tbody>
</table>

*Data assume 1-month follow-up period; does not include sentinel ED visit cost. Values are given in 2010 US dollars.
arm, 100 of the 100 patients get an ICS and 48 are projected to be compliant. Even when we increase the expected follow-up rate to 100% in the usual care arm, we project that only 32 patients will get an ICS and only 15 will be compliant with an ICS after an acute care visit for asthma. This suggests that our traditional preventive care delivery model of recommending follow-up is not an effective way to improve ICS use among children with asthma discharged from the ED.

### Table II. Decision/cost-effectiveness analysis results* for each ICS delivery system applied to cohort of pediatric asthmatics treated in the ED for acute exacerbation

<table>
<thead>
<tr>
<th></th>
<th>ED relapse visits/100 patients</th>
<th>Hospital admissions/100 patients</th>
<th>Direct cost/100 patients</th>
<th>Direct + indirect cost/100 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual care</td>
<td>10.6</td>
<td>2.4</td>
<td>$23,400</td>
<td>$27,100</td>
</tr>
<tr>
<td>Uniform prescribing</td>
<td>9.4</td>
<td>2.2</td>
<td>$20,800</td>
<td>$22,000</td>
</tr>
<tr>
<td>Uniform dispensing</td>
<td>8.4</td>
<td>1.9</td>
<td>$19,100</td>
<td>$20,100</td>
</tr>
</tbody>
</table>

*Data assume 1-month follow-up period; does not include sentinel ED visit cost. Values are given in 2010 US dollars.

### Discussion

This decision tree analysis demonstrates that for a cohort of theoretical patients, the current system for delivering ICS through close outpatient follow-up is less clinically effective and more costly than either of the evaluated alternative options. Patients in the uniform prescribing arm and the uniform dispensing arm had improved rates of ICS delivery and ICS use following an ED visit for asthma. Additionally, both of these groups had lower rates of ED relapse visits and subsequent hospitalizations in the month following the sentinel ED visit compared with the usual care group. Both the direct and total costs attributed to the prescribing and dispensing arms were lower than those attributed to the usual care arm.

We recognize that the decision to initiate controller medication therapy for children with asthma in the ED has historically not been straightforward and has led to significant controversy. This may be due, in part, to the fact that although the GINA guidelines unequivocally state that children with asthma seen in the ED qualify as persistent and should be started on controller medications, the National Heart, Lung, and Blood Institute guidelines do not make clear recommendations regarding

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Figure 2. Tornado diagrams for sensitivity analysis (20% bidirectional variation in model assumptions) of predicted total cost savings. A, Uniform prescribing of ICSs compared with usual care arm. B, Uniform dispensing of ICSs compared with usual care arm.
the initiation of controller therapy at the time of ED discharge. One might argue that hesitancy to diagnose persistent asthma in response to an ED visit in order to preserve diagnostic specificity has led to a loss of sensitivity, resulting in asthmatics being underclassified and, consequently, undertreated. The decision analysis presented here represents a unique perspective on this prolonged debate. This study suggests that either uniform prescribing or dispensing of ICSs at the time of ED discharge represents a clinically and financially sound alternative approach.

The current approach of recommending outpatient follow-up is an inefficient way to improve rates of ICS use among children with asthma for a number of reasons. First, recent studies have highlighted the challenges of improving follow-up rates after ED visits for asthma. In addition, there are low rates of appropriate ICS prescribing in the outpatient setting, low rates of prescription filling, and poor medication compliance. Under the usual care system, only 7% of patients seen in the ED are expected to be compliant with an ICS after an ED visit for acute exacerbation. By overcoming many of the barriers to appropriate ICS use through either uniform prescribing or uniform dispensing at the time of ED discharge, we show that these rates can improve to either 28% or 48%, respectively. Although we are unable to overcome the ultimate barrier of poor medication compliance with this intervention, we believe that an improvement from 7% ICS use to 28% or 48% ICS use is clinically significant and represents a way for acute care providers to effectively contribute to the delivery of preventive care.

We acknowledge that in the ideal situation, preventive care delivered effectively in the primary care setting would serve to prevent ED visits in the first place. However, it has been shown that even with significant and time-intensive interventions at the time of ED visit, follow-up rates remain suboptimal. Zorc et al developed an ED-based intervention that included a letter for the patient to take to his or her PCP, parental viewing of a video regarding the importance of asthma control, and a mailed reminder to follow-up with the PCP. Despite this intensive intervention, the authors found no difference in follow-up rates between the control and intervention groups. We are not advocating that PCPs abdicate their role in the management of this chronic disease. We do believe that if we want to make a significant difference in the rate of controller medication use among children with asthma, we must change our health care delivery system by expanding the delivery of preventive care to the acute care setting.

There are several limitations to this study. First, although we are unable to truly predict what will happen after an ED visit for asthma, decision analysis models take the best current evidence and reasonable assumptions to inform decisions that can have significant clinical and financial impact. The effect of the model assumptions on the projected outcomes are carefully tested by sensitivity analysis. As mentioned earlier, we recognize the decision to initiate controller medication therapy in the ED is controversial. Consistent with the GINA guidelines, this study assumes that all patients treated in and discharged from the ED for an acute asthma exacerbation qualify for a controller medication. The health care utilization costs used in this analysis are taken from South Carolina Medicaid data and may not accurately represent costs in other areas of the United States or costs for other payer populations. In addition, rates of prescription filling and medication compliance have been shown to vary with demographic characteristics and are also likely positively correlated with the quality of asthma education. Subtle variations such as these may not have been completely accounted for in the sensitivity analyses.

Within this decision analysis model, uniform prescribing or dispensing of ICSs at the time of ED discharge for children with acute asthma exacerbation reduces subsequent acute care visits for asthma and yields a significant cost-savings per patient. We believe this novel approach to improving ICS use among children with asthma represents an effective way to deliver preventive care in the acute care setting.
Figure 1. Decision tree for ICS delivery in the ED.