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Potential Savings From Increasing Adherence to Inhaled Corticosteroid Therapy in Medicaid-Enrolled Children

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Abstract

Background—Many asthma-related exacerbations could be prevented by consistent use of daily inhaled corticosteroid therapy (ICS-Rx).

Objectives—We sought to measure the potential cost savings that could accrue from increasing ICS-Rx adherence in children.

Study Design—We measured observed costs for a cohort of 43,156 Medicaid-enrolled children in 14 southern states whose initial ICS-Rx was prescribed in 2007.

Methods—Adherence rates and associated costs were calculated from Medicaid claims. Children were categorized as high or low adherence based on the ratio of ICS-Rx claims filled to total asthma drug claims. Branching tree simulation was used to project the potential cost savings achieved by increasing the proportion of children with ICS-Rx to total asthma Rx ratios greater than 0.5 to 20%, 40%, 60%, 80%, and 100%.

Results—Increasing the proportion of children who maintain higher adherence after initial ICS-Rx to 40% would generate savings of $95 per child per year. An intervention costing $10 per member per month that resulted in even half of the children maintaining high adherence would generate a 98% return on investment for managed care plans or state Medicaid programs. Net costs decreased incrementally at each level of increase in ICS-Rx adherence. The projected Medicaid cost savings for these 14 states in 2007 ranged from $8.2 million if 40% of the children achieved high adherence, to $57.5 million if 80% achieved high adherence.

Conclusions—If effective large-scale interventions can be found, there are substantial cost savings to be gained from even modest increases in real-world adherence to ICS-Rx among Medicaid-enrolled children with asthma.

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Nearly 7 million children (9.3% of population aged 0–17 years) in the United States are currently diagnosed with asthma.[1,2] Asthma is among the top 10 diagnoses leading to emergency department (ED) visits among children, accounting for 641,000 visits in 2010.[3] However, with effective asthma treatment and self-management, most ED visits and hospitalizations related to asthma could be prevented.

While there are many components of an asthma management plan for preventing exacerbations and achieving long-term control, a critical measure is the consistent use of daily anti-inflammatory agents for patients with persistent asthma. Data from randomized controlled clinical trials specifically suggest that inhaled corticosteroid therapy (ICS-Rx) can improve pulmonary function and decrease symptoms,[4,5] as well as decrease the risk of hospital admissions and ED visits.[6,7] According to an expert panel cited by the National Asthma Education and Prevention Program, “ICSs are the most potent and consistently effective long-term control medication for asthma.”[8] In a Canadian observational study, Suissa et al calculated that asthma mortality was reduced by 21% for each additional canister of ICS-Rx used in the previous year, and that discontinuing ICS-Rx also conferred an increased 90-day risk of death.[9] ICS-Rx is more cost-effective than other long-term controller options[10]; however, while daily preventive use of ICS-Rx can have a substantial impact in reducing adverse outcomes, real-world adherence to ICS-Rx among Medicaid-enrolled children is unfortunately quite low.[11,12]

Multidimensional interventions targeting various self-management behaviors (including adherence) have been tested on a small scale, but are costly to implement on a large scale across entire state Medicaid populations. A more targeted approach focusing only on medication adherence using a prescription refill claims data feedback loop might be more cost-effective, but supporting evidence is lacking and programs of this scale are unlikely to be initiated unless there is a plausible expectation of a return on investment (ROI). An understanding of the upper bounds of rational investments in these adherence-boosting interventions and the potential ROI requires estimates of the potential cost savings that could be generated in total Medic-aid claims by reducing preventable hospitalizations and ED visits. Therefore, we undertook this study to simulate the cost impact of achieving various levels of increase in ICS-Rx adherence levels among elementary school–aged children (5–12 years) initially receiving a new ICS-Rx for asthma.

METHODS

Data Sources

Analyses were performed on a cohort of school-aged children with asthma drawn from a 100% sample of 2007 Medicaid Analytic eXtract (MAX) claims data from 14 southern states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Missouri, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia. These data include one-third of the entire US Medicaid population and nearly half of all African American Medicaid enrollees, and focus on a region with high racial/ethnic disparities and relatively poor health outcomes. The personal summary files provided person-level data regarding Medicaid eligibility, enrollment, and total paid claims, while the MAX inpatient (IP), outpatient/other (OT), and prescription drug (Rx) files provided encounter-level claims for all Medicaid-paid services, including hospitalizations, ED visits, OT services, and prescription drugs.

Sampling Frame

There were 839,684 individual persons in the 2007 Medicaid claims data set that met our diagnostic criteria for asthma: individuals with at least 1 IP admission or 2 OT visits on separate dates with a diagnosis code of asthma (*International Classification of Diseases, Ninth Revision, Clinical Modification* code 493.XX, excluding 493.2X). We focused on the 239,167 children with asthma aged 5 to 12 years, because they are amenable to known interventions that include clinical practice improvement, care management, family support, community interventions, and school-based asthma care and policies. Among this cohort of children with asthma, 122,174 (51.1%) had billed claims for ICS-Rx. We then focused on the 43,156 children who had no ICS-Rx claims in the 90 days before their initial ICS-Rx and who received their first ICS-Rx before September 30, 2007, to allow us to track outcomes for at least 3 months after ICS-Rx initiation. To estimate the annual Medicaid costs associated with a full year of children experiencing a new ICS-Rx, we annualized our cohort, estimating 86,312 children with a new ICS-Rx each year in these 14 states.

Model Structure

The basic modeling approach was a decision tree model developed in TreeAge Pro 2012 (TreeAge Software, Williamstown, Massachusetts) to simulate Medicaid costs for children experiencing various outcome possibilities during the 90-day window of observation, including no ED visit and no hospitalization, ED visit only, hospitalization only, and ED visit with hospitalization as a function of high adherence or low adherence to ICS-Rx asthma medications (Figure). The model was structured to reflect total full-year Medicaid-paid amounts for children experiencing this limited range of possible events during the first 3 months after initial ICS-Rx.

The structure of the model in TreeAge is illustrated in the Figure. The first branch is the choice node, reflecting the actual and then the simulated proportion of children who maintain high (ICS-Rx to total asthma Rx claims ≥50%) or low (ICS-Rx to total asthma Rx claims <50%) adherence. Each of these adherence groups then branches into 4 outcome groups based on probabilities determined by the healthcare utilization observed in the Medicaid claims in the 90 days immediately after initiation of ICS-Rx. Ninety-day costs for each outcome group were calculated based on Medicaid-paid claim amounts within each of the 2 simulated adherence groups, plus any prescription drug costs that would be associated with higher adherence levels. Costs were then annualized to represent potential yearly savings if these adherence levels could be sustained.

Model Input Parameters & Variables

The primary input parameters for the model are summarized in Table 1. They include the probability of 2 branches on the choice node—high versus low adherence to asthma ICS-Rx medication—and probabilities of 4 possible outcome states: no ED visit and no hospitalization, ED visit only, hospitalization only, or both ED visit and hospitalization. The probabilities and costs associated with different adherence groups were obtained from the claims data of the full cohort of children with asthma receiving an initial ICS-Rx in the 14 states. Economic outcomes are presented as annual total Medicaid costs per patient associated with different adherence and outcome groups (including added Rx cost of increased adherence levels), adjusted for a 1-year period. The details of these model parameters are presented below:

ICS-to-total asthma medication ratio—Common measures of medication adherence include proportion of days covered or proportion of prescribed days covered, which are useful measures for differentiating provider prescribing rates from patient refill rates.[13] However, such simple measures of adherence can actually increase in parallel with increased refills of rescue medication such as a short acting beta-agonist (eg, albuterol) or an anti-cholinergic (eg, ipratropium), and show a spuriously positive association with ED visit rates. Individuals who have more asthma visits and who receive more asthma rescue medication also have a higher probability of being prescribed an inhaled corticosteroid, and also have a higher probability of having the need for ICS-Rx adherence reinforced at every visit to the physician or pharmacist.

It has become reasonably well accepted in Medicaid-based asthma research to use the ratio of long-term controller prescriptions to total asthma drug prescriptions, which more accurately reflects the benefits of long-term controller drugs on outcomes.[14] The long-term controller to total asthma medication ratio expresses controller medications as a percentage of total asthma medication claims, which includes both controller and short-term reliever medications.[15] This measure has been validated in administrative claims data, including high correlation (0.94) between use of 2-quarter claims and full-year claims.[14] We focused on the specific subset of ICS-Rx as the most important and effective component of long-term controller therapy, using an ICS-Rx to total asthma medication (ICS/TAM) ratio, which we have previously shown to be predictive of risk for asthma-related ED vis-its.[12] We categorized this variable into 2 groups: high ICS/TAM ratio (≥0.5), and low ICS/TAM ratio (<0.5). We first simulated the decision tree model using observed probabilities and adherence, and then ran the simulation raising the proportion of children in the high-adherence arm to 40%, 50%, 60%, 70%, 80%, 90%, and 100% to assess the impact of improving ICS-Rx adherence rates on overall costs and outcomes.

ED visit—ED services are found in IP and OT files depending on whether the Medicaid beneficiary was or was not admitted to the hospital within the 90-day period after ICS-Rx initiation. For those Medicaid beneficiaries seen in the ED but not admitted to the hospital, services were identified from the OT file using revenue center code values of 0450-0459 and 0981. Those who were seen in the ED and admitted to the hospital were identified from the IP file, using revenue center code values of 0450-0459 and 0981. Other charges associated with ED services were identified in the IP file by place of service, coded as ED. We counted all ED visits among children with asthma in our cohort rather than just those ED visits coded with a primary diagnosis of asthma, because some ED visits prompted by increased wheezing or breathing difficulties can be miscoded as a triggering event (eg, an upper respiratory infection), or a complicating event (eg, a secondary pneumonia), or as nonspecific diagnoses (eg, acute bronchitis, reactive airway disease). Since ICS-Rx

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adherence would not be expected to reduce or increase ED visits for causes entirely unrelated to asthma, counting all-cause ED visits would be the more conservative approach and would tend to underestimate the benefits of ICS-Rx adherence. After unduplicating any encounter claims occurring on the same date, we found all ED visits in both IP and OT settings during the follow-up period, and then categorized the ED visit variables as dichotomous (yes/no).

Hospital admission—Hospital admissions were captured in the IP files. We categorized hospital admission as dichotomous (yes/no) and determined the probability of hospital admission for both high-adherence and low-adherence groups.

Cost outcomes—Economic outcomes at the terminal nodes of each branch reflect the projected annual total Medicaid paid amounts for children in each outcome group based on 90-day actual costs for asthmatic children experiencing each outcome category, plus the additional cost of prescription drugs associated with different levels of ICS-Rx adherence. All costs were annualized.

Analysis

Average annual Medicaid costs (mean and 95% confidence intervals) were calculated for children experiencing each outcome using SAS 9.0 (Cary, North Carolina) (Table 2). Cost outcomes were modeled in TreeAge Pro using cost assumptions and observed outcome probabilities as shown in the branching tree model of the Figure. Projections of aggregated regional cost savings to the 14 state Medicaid programs were generated using these cost outcomes (with 95% confidence intervals) and an assumption of 86,312 children receiving new ICS-Rx each year. This was a conservative assumption, because it did not include those children already receiving ICS-Rx during the prior 90 days. A simple ROI calculation was then made to assess the potential ROI of a $10 per child per month intervention to increase to 50% the proportion of children sustaining an ICS/TAM ratio of >0.5 (from a baseline of 33.35%), and to find the break-even point when the cost of the intervention would be precisely matched by cost savings. ROI calculations were made using the following formula:

$$\frac{\text{Cost Savings} - \text{Cost of Intervention}}{\text{Cost of Intervention}}$$

RESULTS

Table 3 shows the potential savings associated with raising the proportion of children who achieve a high ICS/TAM ratio after initial ICS-Rx. Increasing the proportion of children who maintain higher adherence after initial ICS-Rx to 40% would generate savings from decreased utilization of hospitals and EDs ($95 per child per year after subtracting the additional medication cost). Annualizing our count of the number of children receiving a new ICS-Rx (to account for our 3-month enrollment window and 3-month follow-up window) would give us an estimated 86,312 children aged 5 to 12 years who received a new ICS-Rx on Medicaid in 14 southern states in 1 year. The cumulative 1-year savings for these children that would be associated with a modest increase to 40% achieving high adherence would be nearly $8.2 million (95% CI, $8,154,758–$8,235,028). If the proportion of children with high adherence could be raised as high as 80%, the savings would be $666 per child per year in total Medicaid payments, representing a savings of more than $57.5 million for those 14 Medicaid programs. An intervention costing $10 per member per month that resulted in an increase to even half of children maintaining high adherence would generate a 98% ROI for state Medicaid programs or man-aged care plans. Net Medicaid costs decrease incrementally at each level of increase in ICS-Rx adherence.

DISCUSSION

Previous studies of Medicaid-enrolled children with asthma have documented quite low rates of ICS-Rx real-world adherence (ie, measured prescription drug refills) across a population not aware that adherence is being observed.[16,17] Our simulations were based on real-world Medicaid cost and outcomes data stratified by adherence rates. We demonstrate a substantial potential cost savings with even modest improvement in adherence (eg, 40% of children maintaining an ICS/TAM ratio of ≥0.5). Depending on the costs, intensity, and effectiveness of interventions to improve adherence, the cost savings represent a potential ROI for state Medicaid programs or their capitated managed care plans if they invest dollars in increasing ICS-Rx adherence rates.

This assumes that the primary reason for lower utilization and costs among children achieving a higher use of ICS-Rx relative to their total asthma drug use is adherence. It is also possible that children who are adherent on medication may also be more adherent on other aspects of asthma management that are unrelated to medication adherence, such as lifestyle factors and avoidance of environmental triggers. While adherence to ICS-Rx is one biologically and clinically plausible explanation for this association, we are unable to measure other associated behaviors. Therefore, we can only document an association between higher adherence and lower ED visit use, but cannot rule out potential confounding by other positive self-management behaviors in children who also exhibit better adherence.

If adherence to ICS-Rx is one key element of reducing exacerbations and adverse outcomes, are there indeed effective interventions to improve adherence? Studies suggest that various approaches to asthma care management and self-management could be cost-effective. For example, a controlled trial of an intervention in which children received asthma education, treatment, and an assigned nurse demonstrated fewer ED visits and hospitalizations, and lower healthcare charges, for the children in the intervention group.[18] In another randomized control trial of 220 asthmatic children, the intervention group was assigned parent mentors who provided asthma training and peer support. The children in the intervention group were more adherent to controller medications and experienced reduced symptoms and fewer ED visits.[19] Other intervention programs, such as the Harlem Children's Zone Asthma Initiative, showed that community-based programs can reduce environmental triggers and mitigate asthma-related health outcomes, including ED visits.[20] These programs are often broader and have multiple process measures and targeted behaviors (eg, indoor trigger reduction, self-monitoring with peak flow, written action plans) beyond simple ICS-Rx adherence.[21–23] While these may potentially have a broader impact, it is possible that simply focusing on

ICS-Rx adherence could provide a more focused approach to single-behavior change and be a more cost-effective approach in the long run.

What is the cost of these interventions? Few studies have reported costs associated with their interventions, and many of these studies have had a limited sample size. In the parent peer counselor study by Flores et al, the cost per patient was $60.42, with a savings of $46.16 for participants who were more adherent.[19] In a 2-year environmental intervention program conducted in 7 urban locations in the United States with families of 937 school-aged children, the cost of the intervention per family was $1469 (2001 dollars), or $27.57 per additional symptom-free day.[24] A randomized trial with 1033 urban children of an educational intervention focused on controlling environmental triggers cost $337 per patient over 2 years, with an incremental cost-effectiveness of $9.20 per symptom-free day.[25] The costs of these interventions therefore range from $5 per child per month to more than $60 per child per month.

None of these earlier studies demonstrated either the cost or the benefit associated with exclusively focusing on improving medication adherence. Clinical trials and observational studies have long demonstrated that improved use of ICS-Rx can be cost-effective in improving asthma outcomes and decreasing healthcare utilization, even relative to other long-term controller medications.[26–29] Our data suggest that if an intervention could move adherence from baseline performance to a level of half of all children maintaining an ICS/TAM ratio of at least 0.5 at a cost of $10 per child per month, there would be a nearly 100% ROI. If the goal were simply to improve asthma outcomes with a return that covered the cost of the intervention, then programs could afford to spend $19.82 per child per month (zero net cost, zero financial ROI, but decreased adverse health events for children).

Medicaid programs have unique access to almost real-time data from pharmacy claims across their entire Medicaid population, and could potentially create automated ICS-Rx adherence surveillance systems and rapid-cycle feedback loops with costs spread across entire populations. These health information technology systems could potentially generate automatic provider and patient alerts for nonrenewal of ICS-Rx, as well as alerts for asthma-related ED use. Even small increments of increased ICS-Rx adherence would be cost saving. Greater impact could be achieved by linking the high-tech solutions (surveillance and alerts) to “high-touch” solutions, such as primary care case management, community health workers, school nurse/clinic programs, and/or parental peer counselors and group support.

If interventions demonstrate minimal or insufficient gains in ICS-Rx adherence, then we must begin to challenge our assumption that daily ICS-Rx adherence is a realistic population health strategy. While individual children and their families can succeed in achieving high adherence, and reasonable adherence can be achieved in the context of carefully supervised clinical trials, it has yet to be demonstrated that a large population of low-income children with persistent asthma can achieve ICS-Rx adherence rates of even 50%. If affordable interventions cannot move the adherence metric among large populations of low-income children with asthma, then alternative therapies with higher adherence among children (such as daily oral long-term controller medications) might be found to show higher real-world effectiveness, despite having somewhat lower efficacy in controlled clinical trials.

Limitations

Despite the importance of this study, there are some limitations. First, there are the inherent problems associated with the use of claims data. We can tell how often an individual refills an ICS-Rx, but we cannot assure that the medicine was used properly. We also do not have access to clinical parameters such as symptom frequency, peak flow rates, and staging. However, Medicaid claims data do provide cost and outcomes data on a large population sample of asthmatic children, with a capacity to observe real-world prescription refill rates. We also did not have data more recent than 2007. However, these data are quite similar to data being generated in every Medicaid program across the country, with a potential for near real-time data surveillance on both adherence and outcomes.

Future Implications

Further research will be needed to test such a surveillance system and scalable interventions designed to impact all Medicaid-enrolled children with asthma receiving a new ICS-Rx across an entire state. Studies are also needed to explicitly assess the costs, impact on adherence, impact on outcomes, and return on investment (ROI) of various combinations of these high-tech/high-touch strategies for improving adherence to ICS-Rx and reducing preventable adverse outcomes among Medicaid-enrolled children with asthma.

Further research is also needed to calibrate the breadth of intervention (adherence-only interventions vs broader self-management improvement strategies) required to achieve significant outcomes improvement. It is a testable hypothesis that an extremely targeted approach focused specifically on increasing ICS-Rx adherence might have some significant impact with a substantial ROI, but this will need to be rigorously examined in interventional comparative effectiveness research trials. If ROI does indeed drive the dollar level of investment that managed care organizations or state Medicaid programs are willing to invest in outcomes improvement, then a small targeted investment focused on improving adherence might be more likely to show a cost-effective impact on outcomes than if the same dollars were spent on more diffuse efforts. Our analyses provide some benchmarks for gauging a reasonable level of investment in asthma outcomes improvement interventions for managed care organizations or state Medicaid programs seeking to find the synergies between preventing adverse outcomes and achieving cost control or cost reductions.

Finding effective interventions is a major challenge, but the outcomes of this study provide the foundation of a business case to be made for state Medicaid programs and their contracting managed care organizations to take 2 actions simultaneously: 1) use Medicaid claims data as a public health surveillance system or population health management data feedback loop, which provides both adverse outcome sentinel event surveillance (ED visits), as well as actionable information on a highly relevant patient behavior (long-term controller medication refills); 2) invest a reasonable amount of money (as defined by the ROI demonstrated in this analysis) to improve self-management behaviors among children with asthma, with a specific focus on ICS-Rx medication adherence.

CONCLUSIONS

If effective large-scale interventions can be found, there may be substantial cost savings to be gained from increasing real-world adherence to ICS-Rx among Medicaid-enrolled children with asthma. The potential cost-effectiveness of interventions and potential ROI can be measured against these cost projections.

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REFERENCES

1. [Accessed May 7, 2014] Data, statistics, and surveillance: asthma surveillance data. CDC website. http://www.cdc.gov/asthma/asthmadata.htm
2. Barbara, Bloom; Jones, Lindsay I.; Gulnar, Freeman. [Accessed May 7, 2014] Division of Health Interview Statistics, CDC. Summary Health Statistics for U.S. Children: National Health Interview Survey, 2012:4. CDC website. www.cdc.gov/nchs/data/series/sr_10/sr10_258.pdf. Published December 2013
3. National Hospital Ambulatory Medical Care Survey: 2010 emergency department summary tables. [Accessed May 7, 2014] Table 13: twenty leading primary diagnosis groups for emergency department visits, by patient age and sex, United States, 2010. CDC website. http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2010_ed_web_tables.pdf
4. Adams NP, Bestall JC, Lasserson TJ, Jones P, Cates CJ. Fluticasone versus placebo for chronic asthma in adults and children. Cochrane Database Syst Rev. 2008; 8(4):CD003135. [PubMed: 18843640]
5. Van Essen-Zandvliet EE, Hughes MD, Waalkens HJ, Duiverman EJ, Pocock SJ, Kerrebijn KF. The Dutch Chronic Non-specific Lung Disease Study Group. Effects of 22 months of treatment with inhaled corticosteroids and/or beta-2-agonists on lung function, airway responsiveness, and symptoms in children with asthma. Am Rev Respir Dis. 1992; 146(3):547–554. [PubMed: 1355640]
6. Blais L, Suissa S, Boivin JF, Ernst P. First treatment with inhaled corticosteroids and the prevention of admissions to hospital for asthma. Thorax. 1998; 53(12):1025–1029. [PubMed: 10195073]
7. Pauwels RA, Pedersen S, Busse WW, et al. START Investigators Group. Early intervention with budesonide in mild persistent asthma: a randomised, double-blind trial. Lancet. 2003; 361(9363): 1071–1076. [PubMed: 12672309]
8. National Asthma Education and Prevention Program - National Heart Lung and Blood Institute. [Accessed May 7, 2014] Expert Panel Report 3 (EPR3): guidelines for the diagnosis and management of asthma: section 3, component 4: medication;216. NIH website. https://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.htm Published 2007
9. Suissa S, Ernst P, Benayoun S, Baltzan M, Cai B. Low-dose inhaled corticosteroids and the prevention of death from asthma. N Engl J Med. 2000; 343(5):332–336. [PubMed: 10922423]
10. Halpern MT, Khan ZM, Stanford RH, Spayde KM, Golubiewski M. Asthma: resource use and costs for inhaled corticosteroid vs leukotriene modifier treatment—a meta-analysis. J Fam Pract. 2003; 52(5):382–389. [PubMed: 12737772]
11. Capo-Ramos DE, Duran C, Simon AE, Akinbami LJ, Schoendorf KC. Preventive asthma medication discontinuation among children enrolled in fee-for-service Medicaid. J Asthma. 2014; 51(6):618–626. [PubMed: 24580372]

12. Rust G, Zhang S, Reynolds J. Inhaled corticosteroid adherence and emergency department utilization among Medicaid-enrolled children with asthma. J Asthma. 2013; 50(7):769–775. [PubMed: 23734973]

13. Blais L, Kettani FZ, Beauchesne MF, Lemière C, Perreault S, Forget A. New measure of adherence adjusted for prescription patterns: the case of adults with asthma treated with inhaled corticosteroid mono-therapy. Ann Pharmacother. 2011; 45(3):335–341. [PubMed: 21386018]

14. Yong PL, Werner RM. Process quality measures and asthma exacerbations in the Medicaid population. J Allergy Clin Immunol. 2009; 124(5):961–966. [PubMed: 19748660]

15. Broder MS, Gutierrez B, Chang E, Meddis D, Schatz M. Ratio of controller to total asthma medications: determinants of the measure. Am J Manag Care. 2010; 16(3):170–178. [PubMed: 20225912]

16. Camargo CA Jr, Ramachandran S, Ryskina KL, Lewis BE, Legorreta AP. Association between common asthma therapies and recurrent asthma exacerbations in children enrolled in a state Medicaid plan. Am J Health Syst Pharm. 2007; 64(10):1054–1061. [PubMed: 17494905]

17. Finkelstein JA, Lozano P, Farber HJ, Miroshnik I, Lieu TA. Underuse of controller medications among Medicaid-insured children with asthma. Arch Pediatrics Adolescent Med. 2002; 156(6): 562–567.

18. Kelly CS, Morrow AL, Shults J, Nakas N, Strope GL, Adelman RD. Outcomes evaluation of a comprehensive intervention program for asthmatic children enrolled in Medicaid. Pediatrics. 2000; 105(5):1029–1035. [PubMed: 10790458]

19. Flores G, Bridon C, Torres S, et al. Improving asthma outcomes in minority children: a randomized, controlled trial of parent mentors. Pediatrics. 2009; 124(6):1522–1532. [PubMed: 19948624]

20. Spielman SE, Golembeski CA, Northridge ME, et al. Interdisciplinary planning for healthier communities: findings from the Harlem Children's Zone Asthma Initiative. J Amer Planning Assoc. 2006; 72(1):100–108.

21. Carter MC, Perzanowski MS, Raymond A, Platts-Mills TA. Home intervention in the treatment of asthma among inner-city children. J Allergy Clin Immunol. 2001; 108(5):732–737. [PubMed: 11692097]

22. Crain EF, Walter M, O'Connor GT, et al. Home and allergic characteristics of children with asthma in seven U.S. urban communities and design of an environmental intervention: the Inner-City Asthma Study. Environ Health Perspect. 2002; 110(9):939–945. [PubMed: 12204830]

23. Morgan WJ, Crain EF, Gruchalla RS, et al. Inner-City Asthma Study Group. Results of a home-based environmental intervention among urban children with asthma. N Engl J Med. 2004; 351(11):1068–1080. [PubMed: 15356304]

24. Kattan M, Stearns SC, Crain EF, et al. Cost-effectiveness of a home-based environmental intervention for inner-city children with asthma. J Allergy Clin Immunol. 2005; 116(5):1058–1063. [PubMed: 16275376]

25. Sullivan SD, Weiss KB, Lynn H, et al. National Cooperative Inner-City Asthma Study (NCICAS) Investigators. The cost-effectiveness of an inner-city asthma intervention for children. J Allergy Clin Immunol. 2002; 110(4):576–581. [PubMed: 12373264]

26. Wilson EC, Sims EJ, Musgrave SD, et al. Cost effectiveness of leukotriene receptor antagonists versus inhaled corticosteroids for initial asthma controller therapy: a pragmatic trial. Pharmacoeconomics. 2010; 28(7):585–595. [PubMed: 20550224]

27. Stempel DA, Kruzikas DT, Manjunath R. Comparative efficacy and cost of asthma care in children with asthma treated with fluticasone propionate and montelukast. J Pediatr. 2007; 150(2):162–167. [PubMed: 17236894]

28. Bahadori K, Quon BS, Doyle-Waters MM, Marra C, Fitzgerald JM. A systematic review of economic evaluations of therapy in asthma. J Asthma Allergy. 2010; 3:33–42. [PubMed: 21437038]

29. Tan H, Sarawate C, Singer J, et al. Impact of asthma controller medications on clinical, economic, and patient-reported outcomes. Mayo Clin Proc. 2009; 84(8):675–684. [PubMed: 19648384]

Take-Away Points

Substantial cost savings may be gained from even modest increases in real-world adherence to inhaled corticosteroid therapy among Medicaid-enrolled children with asthma. For example:

- Increasing the proportion of children who maintain higher adherence to 40% would generate savings of $95 per child per year.
- An intervention costing $10 per member per month that resulted in an increase to even half of the children maintaining high adherence would generate a 98% return on investment.
- Increasing the proportion of children who maintain higher adherence to 80% would generate Medicaid cost savings of $57.5 million in the 14 states studied.

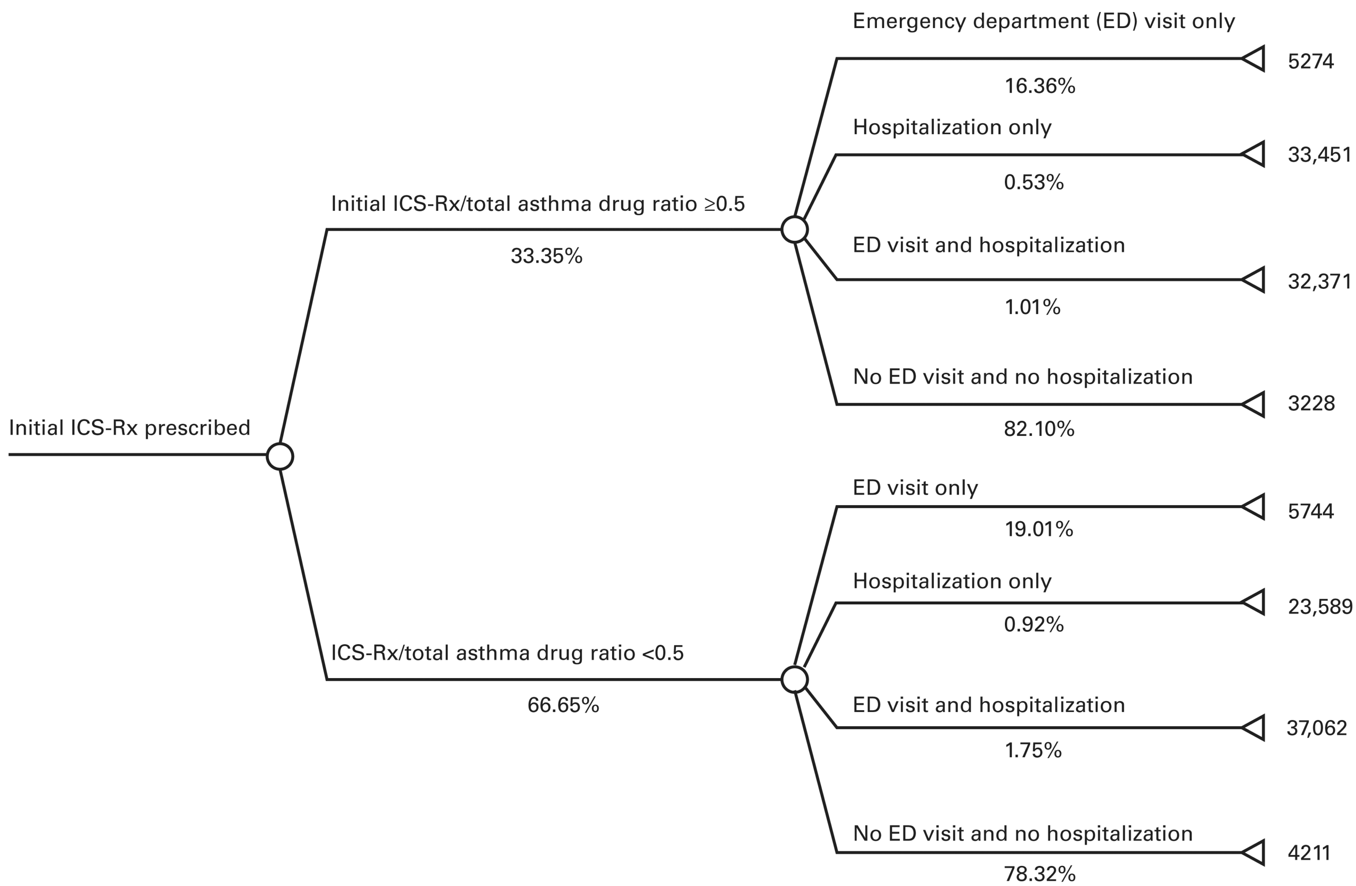

Figure. Model Structure of Decision Tree Analysis

ED indicates emergency department; ICS-Rx, inhaled corticosteroid.

Initial model uses outcomes for observed high adherence rate of 33.3% to establish baseline costs; model then is rerun at simulated proportions of children in high-adherence group of 40%, 60%, 80%, and 100% to assess potential reductions in costs.

Table 1

Input Parameters of Model: Children Aged 5 to 12 Years in 14 States on Asthma Medication, Covered by Medicaid

	Base Model Parameter	Probabilities of Adverse Event
State Transition Probabilities		
High adherence ICS-Rx/total asthma drug ratio (≥0.5)	33.35% (14,391/43,156)	—
Low adherence ICS-Rx/total asthma drug ratio (<0.5)	66.65% (28,765/43,156)	—
Probability of ED visit only	High-adherence group	16.36% (2355/14,391)
	Low-adherence group	19.01% (5467/28,765)
Probability of hospitalization only	High-adherence group	0.53% (76/14,391)
	Low-adherence group	0.92% (265/28,765)
Probability of ED visit and hospitalization	High-adherence group	1.01% (145/14,391)
	Low-adherence group	1.75% (504/28,765)
Probability of neither ED visit nor hospitalization	High-adherence group	82.10% (11,815/14,391)
	Low-adherence group	78.32% (22,529/28,765)

ED indicates emergency department; ICS-Rx, inhaled corticosteroid.

Table 2

Medicaid Cost Assumptions for Outcome States

Medicaid Costs for Each Outcome State		Mean Annual Total Cost (95% CI)
Medicaid-paid costs for children with ED visit only	High-adherence group	$5274 ($4759–$5788)
	Low-adherence group	$6744 ($6301–$7187)
Medicaid-paid costs for children with hospitalization only	High-adherence group	$33,451 ($17,415–$49,488)
	Low-adherence group	$23,589 ($18,199–$28,978)
Medicaid-paid costs for children with both ED visit and hospitalization	High-adherence group	$32,371 ($25,708–$39,035)
	Low-adherence group	$37,062 ($30,877–$43,248)
Medicaid-paid costs for children with neither ED visit nor hospitalization	High-adherence group	$3328 ($3102–$3355)
	Low-adherence group	$4211 ($4094–$4327)

ED indicates emergency department.

Table 3

Effect of Adherence on Medicaid Expenditures per Patient and Aggregated Across 14-State Southern Region

Adherence Model (high adherence = ICS-Rx/ total asthma medication ≥50%)	Expected Annual Cost per Patient: Mean (95% CI)	Difference (projected annual cost savings per patient)	Annual Projected Aggregate Medicaid Savings Across 14 Southern States (n = 409,106): Mean (95% CI)
Actual adherence = 33.35%	$4969.31 ($4633.53–$5304.80)	—	—
40%	$4874.32 ($4538.12–$5210.32)	$94.99 ($94.48–$95.41)	$8,198,777 ($8,154,758–$8,235,028)
50%	$4731.47 ($4394.64–$5068.25)	$237.84 ($236.55–$238.99)	$20,528,446 ($20,417,104–$20,627,705)
60%	$4588.63 ($4251.17–$4926.18)	$380.68 ($378.62–$382.36)	$32,857,252 ($32,679,449–$33,002,256)
70%	$4445.78 ($4107.69–$4784.12)	$523.53 ($520.68, $525.84)	$45,186,921 ($44,940,932–$45,386,302)
80%	$4302.94 ($3964.22–$4642.05)	$666.37 ($662.75–$669.31)	$57,515,727 ($57,203,278–$57,769,485)
90%	$4160.10 ($3820.74–$4499.98)	$809.21 ($804.82–$812.79)	$69,844,534 ($69,465,624–$70,153,530)
100%	$4017.25 ($3677.26–$4357.91)	$952.06 ($946.89–$956.27)	$82,174,203 ($81,727,970–$82,537,576)

ICS-Rx indicates inhaled corticosteroid.