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Out-of-pocket medication costs, medication utilization, and use of healthcare services among children with asthma

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Abstract

Context—Health plans have implemented policies to restrain prescription medication spending by shifting costs towards patients. It is unknown how these policies have affected children with chronic illness.

Objective—To analyze the association of medication cost-sharing with medication utilization and use of hospital services among children with asthma, the most prevalent chronic disease of childhood.

Design, Setting, and Patients—Retrospective study of insurance claims for 8834 children with asthma who initiated asthma control therapy between 1997 and 2007. Using variation in out-of-pocket (OOP) costs for a fixed ‘basket’ of asthma medications across 37 employers, we estimated multivariate models of asthma medication utilization, asthma-related hospitalization, and emergency department (ED) visits with respect to OOP costs and child and family characteristics.

Main Outcome Measures—Asthma medication utilization, asthma-related hospitalizations and ED visits in 365-day follow-up

Results—The mean annual OOP asthma medication cost was $154 (standard deviation, $71). Among 5913 children ages 5 to 18, filled asthma prescriptions covered a mean of 40.9% of days (95% CI 40.2–41.5). In 1-year follow-up, 121 children (2.1%) had an asthma-related hospitalization and 220 (3.7%) an ED visit. Among 2921 children under age 5, mean utilization was 46.2% of days (95% CI 45.2–47.1); 136 children(4. 7%) had an asthma-related hospitalization and 231 (7.9%) an ED visit. An increase in OOP medication costs from the 25th to the 75th

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percentile was associated with a reduction in adjusted medication utilization among children ages 5 to 18 (41.7% of days vs 40. 3%, p = 0.02), but no change among younger children. Adjusted rates of asthma-related hospitalization were higher for children ages 5 to 18 in the top quartile of OOP costs (2.4 hospitalizations per 100 children vs 1.7 in bottom quartile, p = 0.004), but not for children under 5. Annual, adjusted rates of ED use did not vary across OOP quartiles for either age group.

Conclusions—Greater cost-sharing for asthma medications was associated with a slight reduction in medication utilization and higher rates of asthma hospitalization among children 5 years and above.

In recent years, private health plans have attempted to contain medication costs by shifting costs towards patients. [1, 2] Among adults, greater patient medication cost-sharing has been associated with reduced medication use[1–4] and increases in emergency department (ED) visits and hospitalizations.[5–8] Similar data are limited among children,[9, 10] which is surprising given that nearly 45 million children in the United States are privately insured.[11] Although barriers to health care clearly exist for uninsured children,[12] the association of greater medication cost-sharing on the health care decisions insured families make for their children has been overlooked.

We examined how prescription medication cost-sharing among privately insured families was associated with medication and other health care utilization by children in those families. Since greater cost-sharing may be most relevant for children with chronic disease,[1, 13] we focused on asthma, the leading childhood chronic disease. Childhood asthma is associated with avoidable morbidity and mortality and lower quality of life,[14] and medication underutilization is common.[15]

Using longitudinal private insurance data, we identified children with asthma requiring long-acting asthma control therapy. We analyzed the association of out-of-pocket (OOP) asthma medication cost with medication utilization and asthma-related hospitalizations and ED visits. We hypothesized that greater OOP costs would be associated with reduction sin asthma medication utilization and increases in other asthma-related health care services.

METHODS

We obtained data on pharmacy and medical claims from 1997 to 2008 for 37 geographically diverse U.S. employers. These data, obtained from a benefits consulting firm, have been used to explore the association of pharmacy benefit design with medication use by the chronically ill.[1, 2, 6, 16, 17] Each employer offered 1 or more health plans to its active or retired employees and their dependents. The claims data contained information on the use of all medications(including those purchased as 90 -day or mail-order prescriptions)and medical services for the insured population. Because the data were de-identified, the study was exempted from human subjects review by the Institutional Review Boards of the University of Southern California and University of Minnesota.

We identified children with asthma who initiated therapy with a long-acting asthma control medication– inhaled corticosteroids (ICS), long-acting beta-2 agonists (LABA), leukotriene receptor antagonists, combined ICS-LABA formulations, methylxanthines, cromolyn sodium, or immunomodulators – between 1997 and 2007. Although asthma control therapy is intended to be taken daily and year-round by children with persistent asthma, existing guidelines and evidence also support use as -needed (e.g. seasonally).[14, 18] We focused on children requiring control therapy since medication adherence is important to minimizing disease exacerbations[14] and utilization may be related to medication cost-sharing. We restricted our analysis to incident cases of children initiating therapy in an attempt to study children with newly diagnosed persistent asthma.[19]

We first identified all beneficiaries less than 18 years old with asthma based on 2 or more medical claims with an ICD-9 diagnosis code for asthma (493.XX)or 2 or more prescriptions for an asthma medication(N = 60735). Of these children, 41782 filled at least one claim for an asthma control medication. Following prior work, we identified children initiating control therapy by excluding those with a pharmacy claim for a control medication in the prior 6 months (N = 24592 remaining).[19] Within this group, we included only children who were continuously enrolled for at least 1 year after initiating therapy and who re-filled a prescription for an asthma control medication at least once beyond 30 days after initiation (N = 8834).

Our sample selection was intended to identify children with newly diagnosed persistent asthma starting control therapy. Some children may have episodic symptoms for which they are prescribed daily control therapy only seasonally or during periods of exacerbation. [14, 18] Some of these children may be included in our sample if they had no exacerbations requiring control therapy in the prior 6 month period. As a sensitivity analysis, we restricted our sample to include a 12-month period without prior asthma control therapy (N =6404) to create a more homogenous sample of children with presumably newly diagnosed persistent asthma requiring control therapy.

Asthma medication utilization

We followed children for 365 days after the defined date of initiating control therapy. We defined medication utilization as the proportion of 365 days in which control therapy was supplied. For example, if a child filled 6 prescriptions, each providing a 30-day supply, utilization was defined to be fifty percent (180/365 = 49.3%). For children using multiple medications (e.g. an ICS and a LABA), a child was considered to utilize control therapy in a given period if a prescription was filled for either of the 2 medications. In quantifying utilization, not all children in our sample may have been expected to utilize control therapy year-round but rather for a short period after being prescribed therapy. For these children, utilization measured over a 365-day period would be inappropriate. As a sensitivity analysis, we measured utilization in the 90 days following initiation of control therapy to account for children whose expected course of control therapy may have been shorter. We also accounted for children who may have started therapy due to seasonal symptoms by studying children first initiating therapy during the pollen season (defined as April to September). In the seasonal analysis, utilization was defined as the proportion of days in the season in which control therapy was supplied (after initiation).

Asthma-related health services

Asthma-related hospitalizations and ED visits were identified from the medical claims using the primary ICD-9 diagnosis code for asthma. ED visits included those that resulted in patient discharge from the ED as well as hospitalization. For asthma-related hospitalizations, total expenditures were calculated as the sum of payment by the health plan and beneficiary and included facility payments as well as professional service fees.

OOP asthma medication costs

Following prior work,[1, 2, 17] we computed the mean OOP cost within a plan of a representative, fixed ‘basket’ of asthma control medications. Our intent was to capture the OOP prices faced by patients in different plans. We computed OOP costs for a basket of medications for 2 reasons. First, it is difficult to summarize a plan’s OOP cost of a specific medication when tiered formularies, utilization requirements (such as prior authorizations and step-therapy limitations), and in-network and mail-order discounts are common. Second, OOP costs estimated from all OOP medication expenditures – rather than from a fixed basket of medications – may misrepresent the OOP prices faced by patients. For example, consider 2 health plans: the first charges a $5 co-payment for medications 1 and 2, and the second charges a $5 co-payment for medication 1 and a $15 co-payment for medication 2. If all patients in the second plan chose medication 1 because it is cheaper, estimated mean OOP expenditures would be identical across plans despite plan 1 having a more generous pharmacy benefit.

For each plan p in a given year, we calculated the mean annual OOP cost of a 30-day prescription for a medication in class j (e.g. ICS, LABA; Table 2) among all adults and children with asthma, $AvgOOP_{pj}$. Both children and adults were used to compute OOP costs since pharmacy benefits do not depend on whether a medication is dispensed to a child or adult. We applied these plan- and class-specific OOP costs to a representative basket of medications, determined on the basis of usage of all children in our final sample. Specifically, we computed mean annual OOP costs per child for the representative basket of asthma medications in each plan ($PlanRxOOP_p$) and year by weighting plan- and class-specific mean OOP costs ($AvgOOP_{pj}$) with the average number of 30-day prescriptions for each class per child per year in our final sample:

$$\mathrm{PlanRxOOP}_p = \sum_{j=1}^{\#Classes} \mathrm{AvgOOP}_{pj} * \frac{\mathrm{Prescriptions}_j}{\#\mathrm{of\,Children}}$$

The basket of medications was fixed across individuals, allowing for a comparison of the OOP cost of purchasing the basket across different plans (146 plan-years). All dollar amounts were converted to 2010 dollars.

Analysis

We estimated the association between OOP asthma medication cost and medication utilization using a multivariate generalized linear model (GLM) with a logarithmic link function. We adjusted for child and family characteristics and the mean co-insurance rate for non-medication services.[2] Child characteristics included age, gender, an indicator for whether therapy was initiated during pollen season, an indicator for allergic rhinitis, and the number of co-morbidities besides asthma and allergic rhinitis. Disease severity was adjusted for by including counts of asthma -related hospitalizations and ED visits in the 6 months prior to initiating asthma control therapy. Family characteristics included the number of adults in the family and their mean age, the number of additional children insured under the same policy, indicator variables for parental asthma and other co-morbidities, and socio-demographic characteristics of the family’s zip code drawn from the U.S. Census (age distribution of population; percent self-reported white, black, or other; percent self-reported Hispanic; percent with college degree among population under age 65; median income among families with children; and rural/urban composition).[1, 2] Initial options for race were defined by the U.S. Census; however, we defined an “other” category for individuals who did not self-report being “White” or “Black or African American.” The utilization model was estimated separately for children above and below 5 years of age based on greater severity and different treatment guidelines among infants and toddlers with asthma.[14, 20]

We estimated the association between OOP asthma medication cost and asthma-related hospitalizations and ED visits in the 365 days following initiation of asthma control therapy. Asthma-related hospitalizations and ED visits were defined as binary variables, although our results were robust to defining both as count variables. For each outcome, we estimated a multivariate logistic model adjusting for child and family characteristics, disease severity, and mean co-insurance for non-medication services. We also estimated the association of OOP medication costs with total spending (patient + health plan) on asthma-related hospitalizations. Because hospital expenditures were not normally distributed, we estimated the association with expenditures using a 2 -part model[21] which combined estimates of the probability of hospitalization from the logistic model with a GLM estimating inpatient spending among children with at least 1 asthma-related hospitalization. Confidence intervals in the expenditure model were computed by 1000-sample bootstrap. All models included fixed effects for the year of control therapy initiation and census region and were clustered at the employer-year level. Non-significant variables were not omitted from the models.

In addition to sensitivity analyses addressing intermittently prescribed asthma control therapy, we explored whether the association of OOP asthma medication costs with use of health services was confounded by unobserved child or family characteristics such as overall health or underlying propensity to use services. Specifically, we estimated the association between OOP asthma medication costs and non-asthma-related hospitalizations, hypothesizing that greater OOP medication costs should not be associated with greater non-asthma related hospitalizations unless selection bias were present. Moreover, because OOP asthma medication costs varied at the plan-year level, we assessed whether our results were robust to a hierarchical modeling approach with nesting at the employer and plan levels. Finally, we conducted a residual confounding analysis to assess the extent of potential bias– for example, due to unobserved asthma severity among patients in high OOP plans– in our estimates. [22] We assumed a binary unmeasured confounder that was patient specific and independent of measured confounders and investigated the degree of confounding needed to eliminate the estimated association between OOP asthma medication costs and hospitalizations. STATA version 11.2 (STATA Corp, College Station, Texas) was used for statistical analyses and the 95% CI reflects .025 in each tail or $P \leq .05$.

RESULTS

Our sample included 8834 children, 2921 under age 5 (mean age 2.5y) and 5913 between ages 5 and 18 (mean age 9.7y) (Table 1). The majority of children were male(5290; 59.9% of full sample). A minority of children had concurrent diagnoses of allergic rhinitis (1177; 13.3%). Other chronic conditions in addition to asthma or allergic rhinitis were infrequent. For 1436 (16.3%) children in our study, at least 1 other adult family member had asthma. Among both age groups, the most commonly used asthma medications were inhaled corticosteroids (86.3% of children under 5, 75.4% of children ages 5 to 18), followed closely by leukotriene receptor antagonists (Table 2). Combined corticosteroid/long-acting beta agonist preparations were common among the older age group (2004; 33.9%). A substantial proportion of children in both age groups used more than 1 asthma medication (61.8% of children under 5, 60.2% of children ages 5 to 18).

Across plans, the mean OOP cost of the standardized basket of asthma medications per year, $PlanRxOOP_p$, was \$154 (sd \$71)(Table 3). Mean utilization of asthma control therapy was low in both age groups. Among children ages 5 to 18, filled asthma prescriptions covered a mean of 40.9 % (SD 25.1)of days; among children under 5, prescriptions covered 46.2% (SD 26.7) of days (Appendix Table 1). Although child and family characteristics did not vary across plans with differing OOP asthma medication costs (Table 3), unadjusted mean utilization of asthma control therapy fell slightly with higher OOP medication costs. For example, among children ages 5 to 18 in the highest quartile of OOP asthma medication costs, prescriptions covered 41.3% of days compared to 42.2% for children in the lowest quartile (p = 0.34). Annual, unadjusted mean rates of asthma-related hospitalization were greater for children in the highest quartile of OOP asthma medication costs compared to the lowest quartile (2.7% v 1.4%, p = 0.01). In contrast, unadjusted mean rates of asthma-related ED visits were lower for children in the highest quartile of OOP medication cost compared to the first (3.9% vs 4.3%, p = 0.53). Annual, unadjusted mean rates of asthma-related hospitalization and ED visits were greater among children under age 5 (4.7% and 7.9% respectively, Appendix Table 1).

Table 4 shows factors associated with asthma medication utilization from multivariate analysis. Among children ages 5 to 18, mean annual OOP asthma medication costs were negatively associated with utilization over the 365 -day follow-up period (−3.6% relative change (95% CI −6.7% – −0.6%) for each additional $100 in annual OOP costs). By contrast, OOP asthma medication costs were not statistically significantly associated with utilization for children under age 5. Asthma medication utilization declined with child age and utilization was greater for children with allergic rhinitis in both age groups. Asthma-related hospitalizations and ED visits in the 180 days prior to initiating control therapy and zip-code demographics were not statistically significantly associated with medication utilization in either age group at the $p < 0.05$ level. Goodness of fit was assessed based on the Akaike Information Criterion (AIC) statistic (AIC of 0.47 for the model corresponding to children under age 5; 0.21 for the model corresponding to children ages 5 to 18).

Table 5 shows adjusted estimates of asthma medication and other health care service use associated with an increase in OOP asthma medication costs from the 25th to the 75th percentile of OOP costs (from $100 to $190 annually). The inter-quartile increase in OOP asthma medication costs was associated with a small but statistically significant reduction in the percent of days covered by an asthma medication among children ages 5 to 18 (41.7% vs 40.3%, p = 0.02), but no statistically significant change among younger children. Adjusted rates of asthma-related hospitalization were higher for children ages 5 to 18 in the top quartile of OOP asthma medication costs compared to the bottom quartile (2.4 hospitalizations per 100 children vs 1.7, p = 0.004), but no statistically significant difference across quartiles was found for children under 5. There was no statistically significant difference in annual, adjusted rates of ED use between patients in the 25th and 75th percentile of OOP asthma medication costs for either age group.

Averaged across all children with asthma ages 5 to 18, total(patient + health plan) asthma-related hospital expenditures were not statistically significantly different between children in the top and bottom quartiles of OOP asthma medication costs ($ 145 per child in top quartile vs $ 130, p = 0.81; Table 5), while total asthma medication expenditures were statistically significantly lower in the top quartile ($ 242 per child vs $250, p=0.007). Combining both effects, total expenditures per -child on asthma-related medications plus hospitalizations were not statistically significantly different between the 25th and 75th percentile of OOP asthma medication costs ($380 per child vs $387, p = 0.93).

Sensitivity analyses

In addition to adjusting for use of hospital services in the 180 days prior to starting asthma control therapy, we assessed for confounding in the association of OOP asthma medication costs with asthma-related hospitalizations by estimating the association between OOP asthma medication costs and non-asthma-related hospitalizations. OOP asthma medications costs were not statistically significantly associated with non -asthma-related hospitalizations(Table 5). In residual confounding analysis, we computed that the true odds-ratio (OR) of hospitalization with respect to OOP asthma drug costs would become statistically indistinguishable from 1 if there were an unmeasured binary variable with an OR of hospitalization of 2, an 80% prevalence at a top quartile OOP cost plan and 0% prevalence at a bottom quartile OOP plan, a degree of selection felt to be unlikely.

We also explored whether our estimates were affected by the inclusion of children who were not expected to use therapy daily year-round, but only seasonally or on an as-needed basis. Limiting our follow-up period to 90 days and also examining seasonal utilization – both intended to capture short- rather than long-term use – revealed similar associations between OOP asthma medication costs, medication utilization, and asthma-related hospitalizations (Appendix Table 2). Restricting our sample to require a 12-month period without prior asthma control therapy– intended to reduce the probability of including children with prior intermittent use of control therapy – also did not affect the association between OOP medication costs, medication utilization, and asthma-related hospitalizations. Finally, because OOP asthma medication costs varied at the plan-year level, we assessed whether our results were robust to a hierarchical model with nesting at the plan-year levels. Our results were unchanged with this approach.

DISCUSSION

Despite evidence that greater medication cost -sharing is associated with reduced medication utilization and increases in other health care utilization among adults, data are limited among children.[9, 10] We found that greater OOP asthma medication cost was associated with small but statistically significant reductions in medication utilization and total (patient plus health plan) asthma medication expenditures among children with asthma above age 5. No association was found for children younger than 5 years. Higher OOP asthma medication cost was also associated with more frequent asthma -related hospitalizations. However, there was no statistically significant association with ED visits or with total medication plus asthma -related hospitalization expenditures.

Health care utilization by children relies on the purchasing decisions of parents and children with chronic illnesses are susceptible to under -utilization of effective medical therapies.[23] While most child studies focus on the impact of insurance enrollment on those previously uninsured,[12, 24] our study explores whether impediments exist among insured children through greater medication cost-sharing. Our study relates to prior research among children with attention deficit hyperactivity disorder after the introduction of multi-tier formularies,[25] studies investigating the association of socio-demographic and insurance characteristics with asthma medication use,[19, 26, 27] as well as studies of Canadian children with asthma which document lower medication utilization[28] and increased hospitalizations and ED visits associated with greater drug cost-sharing.[29] Our study adds to prior work by examining a large sample of children with asthma in the U.S., where cost-sharing may impact utilization differently than in Canada. We also analyzed the association of medication cost-sharing with both medication and other health care utilization and explored how that association varied with child age. Our finding that greater OOP medication cost was not associated with lower asthma medication utilization among younger children suggests that parents may be less sensitive to medication costs for younger children who traditionally have more severe disease.[20] In addition, parents may play a more active role in disease management for younger children with asthma compared to adolescents.

Our study had several limitations. Unobserved characteristics of children and families may explain the estimated association of OOP costs with medication utilization. However, selection bias is limited by the fact that the majority of employers in our study offered a single, employer-specific drug benefit regardless of the various medical plans they offered. For example, 97% of children had a choice of only a single drug plan from the employer providing coverage to their family. Although we did not have data on employer characteristics, we assessed for family selection into health plans by estimating the association between OOP asthma medication cost and non -asthma-related hospitalizations. If selection bias were important, one would expect greater medication cost-sharing to also be associated with greater non-asthma related hospitalizations. We found no such association. In addition, our estimates were unaffected by adjustment for use of hospital services in the previous 180 days.

The intent of our study was to analyze the association of OOP asthma medication prices with medication utilization. While this would be straightforward if there were only a single medication to treat asthma and plans varied only in their co-payments for the medication, the reality is more complex. Several asthma medications exist and plans vary in benefit designs, requiring the use of a "price index" to depict the prices faced by patients in different plans. Since our approach characterized plan prices by computing the OOP cost required to purchase a fixed, representative basket of asthma medications within a plan, it is possible that the reductions in medication utilization that we estimate in higher cost plans were small because patients shift towards less expensive medications within high cost plans.

Mean utilization of asthma control therapy over a 365-day period was low in our study. A limitation of our sample is that it may have included children who were not expected to use therapy daily year-round, for example if prescribed seasonally or on an as-needed basis. Limiting our follow-up period to 90 days and examining seasonal utilization – both intended to capture short-rather than long -term use – revealed a similar association between OOP medication cost and medication utilization. An additional limitation of our study was that the sample of children, though large, was not representative of all privately insured children. Due to lack of family income data, our study was also unable to reliably assess the impact of income on medication and hospital utilization as done in prior studies.[29] Zip-code level income was not associated with medication utilization, not surprising given the coarseness of the measure. Our study also lacked clinical measures of asthma severity which made exploration of overall asthma-control impossible. Lastly, our measure of medication utilization, days-supplied, may have overstated actual adherence to inhalational therapies [30], though this measurement error should not vary systematically across health plans.

Our results contribute to ongoing discussions about generosity mandates for children. In addition to prohibiting health plans from limiting coverage of children with pre -existing health conditions, the Affordable Care Act (ACA) requires plans to cover preventive health services such as vaccines and well-child visits at zero cost to families.[31] Our study suggests that medication generosity mandates have small effects on utilization and asthma-related hospitalizations, but other strategies to improve medication utilization – such as routine access to primary care and pulmonary specialists, written plans of care for families, and regularly scheduled follow-up appointments– may be important in improving medication utilization.[27] Low levels of medication utilization suggest that parents may not realize the benefits of prescription medications in childhood chronic illness.[32] It is perhaps not surprising that children with asthmatic parents – who are presumably familiar with the importance of consistent medical therapy – had higher utilization of asthma medications than children of parents without asthma. Ultimately, despite its limitations, our study suggests that greater prescription medication cost -sharing among children with asthma may lead to small reductions in utilization of important medications with unintended consequences of more frequent asthma-related hospitalizations.

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TABLE 1

Characteristics of children with asthma and their families

	Full sample	Age < 5	Ages 5–18
N	8834	2921	5913
Child characteristics			
Mean age, y (sd)	7.3 (4.5)	2.5 (1.2)	9.7 (3.6)
Male, No. (%)	5290 (59.9)	1825 (62.5)	3465 (58.6)
Allergic rhinitis, No. (%)	1177 (13.3)	379 (13.0)	798 (13.5)
Chronic conditions in addition to asthma/allergic rhinitis, Median (range)	0 (0–3)	0 (0–3)	0 (0–3)
Family characteristics			
Mean no. adults per child, (SD)	1.9 (0.5)	1.8 (0.4)	1.9 (0.5)
Mean age of adult, y (SD)	38.5 (6.2)	35.3 (5.3)	40.1 (6.0)
Mean no. additional children insured (SD)	1.1 (1.0)	0.9 (0.9)	1.2 (0.9)
Live in northeast, No (%)	1910 (21.6)	594 (20.3)	1316 (22.3)
Live in mid-west, No (%)	1577 (17.9)	444 (15.2)	1133 (19.2)
Live in west, No. (%)	1226 (13.9)	384 (13.1)	842 (14.2)
Live in south, No. (%)	4121 (46.7)	1499 (51.3)	2622 (44.3)
At least 1 adult with asthma, No. (%)	1436 (16.3)	478 (16.4)	958 (16.2)
Characteristics of child's zip code			
Under age 18, % (SD)	25.9 (2.5)	25.8 (2.6)	25.9 (2.5)
Above age 65, % (SD)	11.7 (3.5)	11.6 (3.6)	11.8 (3.4)
Urban residence, % (SD)	80.4 (19.4)	81.4 (19.4)	79.9 (19.4)
White, % (SD)	78.9 (13.1)	77.7 (13.3)	79.4 (12.9)
Black, % (SD)	10.5 (10.6)	11.5 (11.2)	10.0 (10.3)
Hispanic, % (SD)	11.2 (12.1)	11.8 (12.5)	10.9 (11.9)
Under age 65 with more than high school education, % (SD)	25.7 (8.5)	25.9 (8.7)	25.5 (8.4)
Annual family income, $ Median (range)	55469 (24547–135244)	55273 (24547–135244)	55565 (24693–120307)

Notes: Characteristics of child's zip code are obtained from Census data at the 3-digit zip code level.

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TABLE 2

Utilization of asthma medications by mechanism of action

	Age < 5 No. (%)	Ages 5–18 No. (%)
N	2921	5913
Medication category		
Inhaled corticosteroids (ICS)	2522 (86.3)	4458 (75.4)
Leukotriene receptor antagonists	2053 (70.3)	3695 (62.5)
Long-acting beta-2 agonists (LABA)	78 (2.7)	348 (5.9)
ICS/LABA combination	266 (9.1)	2004 (33.9)
Cromolyn sodium/nedocromil	177 (6.1)	269 (4.6)
Methylxanthines	3 (0.1)	30 (0.5)
Immunomodulators	1 (0.1)	11 (0.2)
Use greater than 1 medication	1805 (61.8)	3560 (60.2)

TABLE 3

Child and family characteristics and medication and hospitalutilization by quartile of OOP cost for asthma medications, children ages 5–18

	Full sample	Quartile 1	Quartile 2	Quartile 3	Quartile 4
N	5913	1436	1502	1478	1497
Child and family characteristics					
Mean age, y (sd)	9.7 (3.6)	9.6 (3.6)	9.7 (3.5)	9.6 (3.5)	9.7 (3.6)
Male, No. (%)	3465 (58.6)	881 (61.4)	851 (56.7)	849 (57.4)	884 (59.1)
Allergic rhinitis, No (%)	798 (13.5)	203 (14.1)	209 (13.9)	169 (11.4)	217 (14.5)
Chronic conditions in addition to asthma/allergic rhinitis, Median (range)	0 (0–3)	0 (0–2)	0 (0–3)	0 (0–3)	0 (0–2)
Mean no. adults per child, (SD)	1.9 (0.5)	1.9 (0.5)	2.0 (0.5)	1.9 (0.5)	1.9 (0.5)
Mean age of adult, y (SD)	40.1 (6.0)	40.1 (6.2)	40.6 (6.0)	40.1 (5.8)	39.8 (5.8)
At least 1 adult with asthma, No. (%)	958 (16.2)	218 (15.2)	261 (17.4)	237 (16.0)	242 (16.2)
Mean no. additional children insured (SD	1.2 (1.0)	1.1 (1.0)	1.2 (1.0)	1.2 (1.0)	1.2 (1.0)
Mean non-medication coinsurance rate (SD)	25.6 (11.6)	21.0 (8.5)	25.1 (12.4)	29.0 (12.1)	27.3 (11.2)
Medication utilization					
Annual OOP cost for basket of asthma medications, $ Mean (SD)	154 (71)	89 (17)	123 (24)	161 (32)	242 (73)
Days covered by an asthma prescription during 365-day follow-up, % (SD)	40.9 (25.1)	42.2 (25.8)	40.7 (24.4)	39.4 (24.1)	41.3 (25.8)
Health care utilization after initiating control therapy					
Asthma-related hospitalization during 365-day follow-up, No. children (%)	121 (2.1)	20 (1.4)	28 (1.9)	33 (2.2)	40 (2.7)
Asthma-related emergency department visit during 365-day follow-up, No. children (%)	220 (3.7)	62 (4.3)	52 (3.5)	48 (3.3)	58 (3.9)
Health care utilization prior to initiating control therapy					
Asthma-related hospitalization in 180 days prior to initiating control therapy, No. children (%)	129 (2.2)	28 (2.0)	31 (2.1)	39 (2.7)	31 (2.1)
Asthma-related emergency department visit in 180 days prior to initiating control therapy, No. children (%)	195 (3.3)	37 (2.6)	47 (3.1)	61 (4.1)	50 (3.3)

Notes: Table reports unadjusted analyses. Annual OOP cost and expenditures on hospitalization are in 2010 dollars. Mean non-medication coinsurance rate is the mean OOP cost of all medical services (e.g. hospitalizations, ED visits, durable equipment, etc.) divided by the total payment (OOP + health plan) for those services. The 25th, 50th, and 75th percentiles of Annual OOP cost for asthma medications were $100, $140, and $190 respectively.

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TABLE 4

Factors associated with asthma medication utilization according to age of child

	Age < 5		Ages 5–18	
	Unadjusted mean % of days covered by a prescription asthma medication (95% CI)	**Adjusted relative % change in days covered by a prescription asthma medication (95% CI)**	**Unadjusted mean % of days covered by a prescription asthma medication (95% CI)**	**Adjusted relative % change in days covered by a prescription asthma medication (95% CI)**
Increase in annual OOP cost for basket of asthma medications by $100	-	−1.3 (−4.5–2.0)	-	−3.6 (−6.5–−0.6)
Child characteristics				
Increase in age of child by 1 year	-	−1.5 (−3.4–0.4)	-	−1.7 (−2.2–−1.3)
Gender				
Male	47.2 (45.9–48.4)	5.4 (1.2–9.7)	41.3 (40.5–42.2)	1.9 (−1.0–4.9)
Female	44.5 (43.0–46.0)	-	40.2 (39.3–41.2)	-
Allergic rhinitis				
Yes	49.7 (46.8–52.6)	11.1 (4.6–18.1)	46.3 (44.4–48.1)	14.3 (9.9–18.92)
No	45.6 (44.6–46.7)	-	40.0 (39.4–40.7)	-
Increase in no. of chronic conditions in addition to asthma or allergic rhinitis by 1	-	7.7 (0.5–15.4)	-	3.8 (−1.9–9.9)
Increase in asthma-related hospitalizations in 180 days prior to starting control therapy by 1 visit	-	7.5 (−0.9–16.7)	-	9.5 (−1.4–21.6)
Increase in asthma-related ED visits in 180 days prior to starting control therapy by 1 visit	-	1.5 (−2.4–5.5)	-	2.4 (−1.3–6.3)
Family characteristics				
Adult with asthma				
Yes	46.8 (44.5–49.2)	3.8 (−1.9–10.0)	43.5 (41.8–45.1)	8.7 (4.5–13.1)
No	46.0 (45.0–47.1)	-	40.4 (39.7–41.1)	-

Notes: Unadjusted mean percent of days covered by a prescription asthma medication are displayed for categorical variables. Adjusted relative % change in days covered by asthma medication was estimated from a multivariate, generalized linear model with annual OOP costs for a representative basket of asthma medications, non-medication cost sharing, child and family characteristics, indicators for the year corresponding to control therapy initiation, and zip-code demographic characteristics. Additional child, family, and zip-code demographic characteristics adjusted for are described in the Methods.

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TABLE 5

Adjusted asthma medication and other health care utilization associated with an increase in OOP asthma medication costs

	Annual OOP cost for asthma medications		
	25th Percentile ($100)	75th Percentile ($190)	
	Mean (95% CI)	**Mean (95% CI)**	**p-value**
Age < 5			
% of days covered by a prescription asthma medication	46.5 (45.2–47.8)	45.9 (44.8–47.1)	0.44
Total expenditure on asthma medications, $	279 (194–364)	276 (192–360)	0.50
Rate of asthma-related hospitalizations per 100 children	4.9 (4.1–5.8)	4.5 (3.5–5.3)	0.43
Total expenditure on asthma-related hospitalizations among all children in sample, $	246 (164–328)	224 (141–307)	0.71
Total expenditure on asthma-related hospitalizations and medications among all children in sample, $	525 (407–644)	500 (383–617)	0.67
Rate of asthma-related emergency department visits per 100 children	7.4 (6.4–8.4)	8.4 (7.3–9.5)	0.12
Rate of non-asthma-related hospitalizations per 100 children	5.5 (4.4–6.6)	5.2 (4.2–6.2)	0.62
Ages 5–18			
% of days covered by a prescription asthma medication	41.7 (40.7–42.7)	40.3 (39.4–41.3)	0.02
Total expenditure on asthma medications, $	250 (176–324)	242 (170–314)	0.007
Rate of asthma-related hospitalizations per 100 children	1.7 (1.3–2.1)	2.4 (1.9–2.8)	0.004
Total expenditure on asthma-related hospitalizations among all children in sample, $	130 (5–255)	145 (41–250)	0.81
Total expenditure on asthma-related hospitalizations and medications among all children in sample, $	380 (236–523)	387 (260–514)	0.93
Rate of asthma-related emergency department visits per 100 children	3.8 (3.2–4.4)	3.7 (3.0–4.3)	0.74
Rate of non-asthma-related hospitalizations per 100 children	3.2 (2.6–3.7)	2.7 (2.1–3.3)	0.30

Notes: Annual OOP cost and expenditures are in 2010 dollars. Total expenditures are sum of payments by patient and health plan.

APPENDIX TABLE 1

Medication and other health care utilization by quartile of OOP cost for asthma medications, children under 5 years

	Full sample	Quartile 1	Quartile 2	Quartile 3	Quartile 4
N	2921	769	707	730	715
Annual OOP cost for basket of asthma medications, $ Mean (SD)	151 (72)	89 (17)	118 (24)	161 (34)	241 (73)
Mean non-medication coinsurance rate (SD)	24.2 (10.7)	20.6 (7.5)	22.9 (11.4)	27.0 (10.7)	26.7 (11.4)
Medication utilization					
Days covered by an asthma prescription during 365-day follow-up, % (SD)	46.2 (26.7)	47.9 (26.8)	46.0 (26.4)	43.9 (26.3)	46.8 (26.7)
Health care utilization after initiating control therapy					
Asthma-related hospitalization during 365-day follow-up, No. children (%)	136 (4.7)	39 (5.1)	39 (5.5)	23 (3.2)	35 (4.9)
Asthma-related emergency department visit during 365-day follow-up, No. children (%)	231 (7.9)	53 (6.9)	57 (8.1)	60 (8.2)	61 (8.5)
Health care utilization prior to initiating control therapy					
Asthma-related hospitalization in 180 days prior to initiating control therapy, No. children (%)	162 (5.6)	38 (4.9)	47 (6.7)	34 (4.7)	43 (6.0)
Asthma-related emergency department visit in 180 days prior to initiating control therapy, No. children (%)	207 (7.1)	54 (7.0)	50 (7.1)	54 (7.4)	49 (6.9)

Notes: Table reports unadjusted analyses. Annual OOP cost and expenditures on hospitalization are in 2010 dollars. Mean non-medication coinsurance rate is the mean OOP cost of all medical services (e.g. hospitalizations, ED visits, durable equipment, etc.) divided by the total payment (OOP + health plan) for those services. The 25^{th}, 50^{th} and 75^{th} percentiles of Annual OOP cost for asthma medications are $100, $140, and $190 respectively.

APPENDIX TABLE 2

Sensitivity analysis of association between OOP asthma medication costs and asthma medication utilization and asthma -related hospitalizations, children ages 5–18

	Annual OOP cost for asthma medications		
	25th percentile ($100) Mean (95% CI)	75th percentile ($190) Mean (95% CI)	p-value
Follow-up period of 90 days (rather than 365 days)			
% of days covered by an asthma medication prescription	63.2 (62.1–64.2)	62.0 (61.1–62.8)	0.02
90-day rate of asthma-related hospitalization per 100 children	0.5 (0.3–0.7)	0.8 (0.5–1.1)	0.04
Requirement of 12 months without control therapy (rather than 6 months) to be included in sample			
% of days covered by an asthma medication prescription	42.3 (41.2–43.5)	40.8 (39.8–41.8)	0.03
Annual rate of asthma-related hospitalizations per 100 children	1.4 (1.1–1.8)	2.2 (1.6–2.7)	0.007
Sample restricted to children initiating therapy during pollen season (April to September)			
% of days covered by an asthma medication prescription	44.4 (43.2–45.6)	43.0 (42.0–44.0)	0.03

Notes: Annual OOP cost and expenditures on hospitalization are in 2010 dollars. Requirement of 12 months without control therapy (rather than 6 months) reduces sample to 4,502 children. Restricting sample to children initiating therapy during pollen season reduces sample to 2,715 children.

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APPENDIX TABLE 3

Sensitivity analysis of association between OOP asthma medication costs and asthma medication utilization and asthma-related hospitalizations, children ages 5–18 using a hierarchical model with nesting at the plan-year levels

	Annual OOP cost for asthma medications		
	25th percentile ($100) Mean (95% CI)	**75th percentile ($190) Mean (95% CI)**	**p-value**
Hierarchical Model with Nesting at Plan-Year Levels			
% of days covered by an asthma medication prescription	34.8 (34.0–35.6)	33.7 (33.0–34.3)	0.005
Rate of asthma-related hospitalizations per 100 children	1.7 (1.2–2.2)	2.3 (1.9–2.7)	0.03