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Short Title: Long-Term Asthma Control

Impact of Type of Health Care Provider on Long Term Asthma Control

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Abstract

Objective: Asthma prevalence is high and adherence to asthma guidelines is still less than adequate. The main objective of this study was to determine if there were significant differences in outcome measures if asthma care was provided per guidelines either by physicians (pediatric pulmonologists) or specialty trained advance practice nurses (APNs)

Methods: This was a three-year, prospective cohort study of children referred by their primary care providers to a tertiary care center for better asthma control. Patients were provided asthma care per NAEPP guidelines including asthma education. Results were compared over time **and** between patients followed by physicians or APNs. Alpha level of significance was ≤ 0.05 .

Results: The sample included 471 children, ages 2-17 years (mean= 6.4 ± 2.4 years). Physicians and APN's provided asthma care. Of the 471 children enrolled in the study, 176 (37%) were followed for the full three-year study period. At the initial visit, physician group reported more short courses of oral steroids and more unscheduled visits to PCP for acute asthma care in the past 6 months compared to those followed by APNs ($p < 0.05$ for all). Among the total cohort and both subgroups, there were significant improvements in mean Asthma Control Test (ACT), acute care need and mean days/month with asthma symptoms over a three-year period ($p < 0.05$). There was significantly more improvement in use of oral steroids and urgent care visits in physician group ($p < 0.05$).

Conclusion: When asthma guidelines are followed, improvements in asthma control are achieved in children in both the MD and APN groups

Key Words: asthma, children, primary care, provider

Abbreviations:

ACT: Asthma Control test

APN: Advance Practice Nurse

NAEPP (EPR-3): National Asthma Education and Prevention Program (Expert Panel Report-3)

PCP: Primary care providers

% predicted FEV₁: percent predicted forced expiratory volume in one second

Introduction:

Asthma is a common chronic disease in children and is associated with various levels of morbidity.¹ By improving adherence to **evidence-based** guidelines, asthma control can be improved.¹⁻⁴ Among the many barriers to using the guidelines, lack of time and busy schedules are important factors for physicians.⁵ Other providers, such as advanced practice nurses (APN), can help in improving asthma outcomes. The purpose of this study was to evaluate improvements in asthma control outcomes over a 3-year period, and test whether asthma outcomes were similar between physicians and APNs. If this model of teamwork is successful and applied to primary care practices, it may save time and expenses for primary care providers (PCP), alleviate their busy schedules, and improve asthma outcomes in their practices. If successful, it can also be adapted for use with other chronic health care problems.

In a previous study, we have shown that once asthma guidelines are followed, asthma outcomes improve, and severity of asthma at the time of diagnosis (initial visit) was not a significant factor in long term asthma control.⁶ This study is a secondary analysis of our previously reported data. Asthma control outcomes included the mean Asthma Control Test (ACT) scores, **mean acute health care utilization** (hospital admissions, emergency department (ED) visits, urgent care (UC) visits and visits to primary care providers (PCP) for acute asthma exacerbations during the study duration. Outcomes also included the mean number of days/month with asthma symptoms (wheezing, nighttime cough, exercise related symptoms), school days missed and albuterol use over the three-year study period. We compared asthma outcomes **over time and** between patients followed by physicians (pediatric pulmonologists) and specialty trained APNs working in close collaboration as a team in pediatric pulmonary asthma clinics.

Methods:

Design: This was a three-year prospective longitudinal observational cohort study of caregivers and children with asthma referred to pediatric pulmonary at a tertiary care children's hospital for better asthma control. Providers were either one of 2-3 pediatric pulmonologists, or one of 2-3 pediatric pulmonary specialty trained advance practice nurses (APN) working in collaboration with pulmonologists in pediatric asthma clinics. Patients were often followed **by** their providers throughout the study. Patients were also seen at each visit by respiratory therapists who were certified asthma educators. Children and families received asthma education and adequate therapy to achieve and maintain asthma control. Asthma care was given per the NAEPP (EPR-3) asthma guidelines.

Participants: This study was approved by the hospital Institutional Review Board (IRB11-00174). Participants were children with persistent asthma referred by their primary care providers, between January 2011 and December 2015 for better asthma control. Inclusion criteria for this study were children ages 2 to 17 years with persistent asthma who returned to our **specialty asthma clinic** for follow-up appointments (every 3-6 months). Exclusion criteria included intermittent asthma, children with comorbidities such as prematurity, bronchopulmonary dysplasia, cardiac issues, developmental delays, sickle cell disease or any other chronic pulmonary diagnosis such as cystic fibrosis **or** interstitial lung disease. The children were accompanied by **parents or guardians** who could communicate in English. Written consent and assent were waived by the IRB.

Intervention: Scheduling staff made initial appointments with either physicians or specialty APNs based on the first-available appointment unless **the** PCP or family specifically requested that **the** patient **needed** to be seen by a physician. Patients were often followed by the same provider throughout the study period. Families had option to switch providers but very few (n=6) switched. All providers worked in close collaboration as a team and **discussed** difficult cases before developing a management plan. Providers were always available as a resource for each other throughout the study. At each follow-up visit (every 3–6 months as determined by the provider), patients received an assessment for asthma control as well as recommended treatment according to NAEPP asthma guidelines.⁴ Patients and **their** caregivers received asthma education, including their individualized asthma action plan. Specific education was provided on asthma control expectations, asthma triggers and exposure avoidance and self-management strategies at home and asthma medications, including detailed demonstration and dispensing of appropriate spacer devices. Follow up appointments were scheduled at the end of each visit. Medication adherence was discussed at each visit. If response to therapy was less than adequate, if needed, the patient's pharmacy was called to obtain a medication refill history. The refill history was discussed with the family in a non-confrontational manner. Parents and older children were encouraged to be part of the asthma team to improve individual adherence. **The children's** primary care providers were updated through a formal letter after each clinic visit on clinical progress and changes in plan including medications.

Instruments: Asthma Clinical Outcome Measures

Demographic and clinical data were collected at the first clinic visit including age at diagnosis, age at first visit, duration of symptoms, gender, race/ethnicity, family history of asthma, second-hand smoking exposure, and pets in the home. Asthma severity was categorized by providers as mild persistent, moderate persistent, or severe persistent.

Caregivers and older patients (more than 12 years old) completed a questionnaire at each visit (every 3-6 months) which included both primary outcome (ACT score) and secondary outcomes such as **frequency of** acute health care utilization (defined as number of hospital admissions, ED visits, urgent care (UC) visits, PCP visits for acute symptoms, school days missed, and number of courses of oral steroids) and frequency of symptoms (defined as mean number of days per month of albuterol use for acute asthma symptoms, mean number of days/month with daytime wheezing or nighttime cough or exercise-related limitations) since last visit. For children ages 4-11 years, the Childhood Asthma Control Test™ (cACT)⁷ was completed by parents while children filled their section with the help of parents. Patients 12 years and older completed their own ACT questionnaire⁷ to evaluate asthma control over the past four weeks. Five items (amount of time asthma interfered with age-appropriate activities of daily living, frequency of shortness of breath, frequency of nighttime symptoms, frequency of albuterol use, and level of asthma control) were scored on an ordinal scale of 1 to 5 and summed for a total ACT score. Low scores (below 19) indicate not well-controlled asthma. In children older than 5 years of age, percent predicted FEV1 was evaluated by spirometry every 6-12 months and if **the** provider thought there **was** a need. Pulmonary function tests (Spirometry) were done by respiratory therapists in the pulmonary function test (PFT) lab.

Statistical Analysis

Data were collected at the first clinic visit (baseline), then at the 3, 6, 9, 12, 18, 24, 30-and 36- month follow-up visits, as determined by the provider. Baseline data collected at the initial visit reflected the frequency of children's symptoms at baseline and use of acute care services during the previous 6 months. Because follow-up visits were scheduled 3 to 6 months apart, data were categorized in the following manner: the 9- or 12-month visit was the "1-year" follow-up, the 18- or 24-month visit

was the “2-year” follow-up, the 30- or 36-month visit was the “3-year” follow-up. Missing data values were not imputed.

The distribution of scores was measured by frequency and percentage or mean and standard deviation depending upon the level of data. Univariate statistics were used to evaluate differences between physicians and APNs in demographic and clinical characteristics of the children at each clinic visit. Generalized estimating equations were used to compare levels of improvement in asthma control indicators of the total sample over the three-year period, and between children followed by physicians and APNs over time. These analyses yield Wald’s chi square and p-values. SPSS v.25 (IBM Analytics, Armonk, NY) was used for all analyses. The alpha level of significance for all analyses was ≤ 0.05 .

Results

Six hundred eighty-three (683) patients were referred for persistent asthma during study period. Among them, 471 were included in the study. Among the excluded 212 patients, 15 (7%) had intermittent asthma, 75 (35%) had significant co-morbidities, 70 (33%) patients did not show up for their follow-up appointments, and the remaining 52 (25%) patients did not fill out the questionnaire **and** thus were not included in the analysis. Our study sample included 471 children, ages 2-17 years (mean = 6.4 ± 2.4 years) at the first visit. Males comprised 60.1% (n=283) of the sample. Asthma severity included mild persistent asthma (n=106, 22.5%), moderate persistent asthma (n=324, 68.8%), and severe persistent asthma (n=41, 8.7%). Two-thirds of the children were Caucasian (n=314, 66.7%) and 26.8% were African American (n=126). The remaining sample was comprised of Hispanic children (n=31, 6.6%). Mean age at diagnosis was 2.4 ± 4.1 years. Average duration of symptoms at the first visit was 4.1 ± 3.5 years. In our subspecialty asthma clinic, physicians provided care for 217 (46%) children and APNs provided care for 254 (54%) children. At the initial visit (baseline), there were no significant differences in demographic characteristics between patients followed by physicians or APNs (Table 1). At baseline, children cared for by physicians compared to APNs had significantly more short courses of oral steroids in last six months (3.1 ± 3.2 vs. 2.3 ± 2.6 , $p = .002$), more unscheduled primary care visits for acute asthma in last six months (5.7 ± 5.1 vs. 3.3 ± 5.9 , $p < .001$) (Table 2), and more days/month with exercise limitations (10.4 ± 11.6 vs. 8 ± 10.6 , $p = .018$) (Table 3) suggesting that at baseline, children in physician group had more uncontrolled asthma compared with children in APNs group.

Our sample size decreased over the three-year period. **Compared to 471 children at baseline**, at the end of 1st year, the total number of patients were 396 (84%) and among them 190 (48%) were followed by physicians and 206 (52%) were followed by APN’s. At the end of 2nd year, the total number of patients decreased to 257 (55%) and among them 116 (45%) were followed by physicians and 141 (55%) were followed by APN’s. At the end of 3rd year, the total number of patients decreased to 176 (37%) and among them 83 (47%) were followed by physicians and 93 (53%) were followed by APN’s.

Throughout the study duration, the percentage of participants followed by physicians ranged from 45-48% and the remaining 52-55% were followed by the APN’s. There was no significant change in percent of patients followed by physicians or specialty APNs over the three-year study period. Similarly, there was no significant change in percentage of children with mild, moderate, or severe persistent asthma in the total cohort and in both study groups over the three-year follow-up period.

Twelve asthma outcome indicators were compared over three-year follow-up period including the primary outcome measure of Asthma Control Test (ACT). At baseline, when compared between groups, there were no significant differences between the mean number of hospital admissions, emergency department visits, urgent care visits (Table 2), mean ACT scores, mean %predicted FEV1

(Table 4), mean missed school days/month due to acute asthma symptoms, mean number of days/month with either nighttime cough, or daytime wheezing, or albuterol use between the groups of patients followed either by physicians or specialty APNs (Table 3).

Both groups improved significantly within 3-6 months and improvement persisted throughout the three-year follow-up period in both groups (Tables 2-4). There was significant improvement in both groups in mean ACT scores, acute care need (mean number of hospital admissions, emergency department visits, urgent care visits, unscheduled visits to PCP for acute asthma care, short courses of oral steroids), school days missed, and day to day symptom scores (mean number of days/month with either nighttime cough, or daytime wheezing or exercise related symptoms) and mean number of days/month of albuterol use in patients followed either by physicians or specialty APNs (Table 2-4). The only parameter with no significant change over time was %predicted FEV1 as it was normal at baseline in both groups. There was significantly more improvement in mean short courses of oral steroids ($p=0.001$), mean urgent care visits ($p=0.023$), mean unscheduled visits to primary care for acute asthma ($p=0.006$) (Table 2), and mean number of days/month with exercise related symptoms ($p=0.049$) (Table 3) among children followed by physicians compared to those followed by APNs. As children in physician group had more uncontrolled asthma compared with children in APNs group at baseline, it might have played a role in significantly better rate of improvement in physician group over time.

A comparison of demographic and clinical characteristics of children who completed treatments throughout the 3 year ($n=176$) with those who were lost to follow-up ($n=295$) indicated that there were no differences in gender, family history of asthma, smoke exposure, having a pet at home or type of provider (physician or APN) between the groups (Table 5). Children who were lost to follow-up during the three-year duration of the study, were more likely to be Caucasians, had mild persistent asthma and were older at baseline ($p<0.05$ for all). Patients with moderate or severe persistent asthma, African American and Hispanic children were more likely to continue their follow-up compared to Caucasian and children with mild persistent asthma (Table 5).

Discussion:

Our current study focused on changes in asthma control over time among children whose treatment followed NAEPP asthma guidelines. In this sub-group analysis, we compared the effect of type of health care provider (pediatric pulmonary specialty advanced practice nurses vs. pediatric pulmonary physicians) on long term asthma control. The results of this study suggest that by providing guideline-based asthma care, including an appropriate level of therapy based upon asthma control, action plans, and asthma education for families, asthma control does improve irrespective of type of health care provider. Physicians and specialty APNs followed the same guidelines as a team and had similar clinical outcomes with significant improvement in asthma control over time. There was significant improvement in both groups in eleven out of twelve asthma outcomes over time. One remaining outcome was mean %predicted FEV1 which was within normal limits at baseline in both groups. Compared to children followed by APNs, children in the physician group experienced significantly more improvement in mean short courses of oral steroids for acute asthma, mean urgent care visits for acute asthma, mean unscheduled primary care visits for acute asthma and also less days/month with exercise limitations in three-year follow-up period ($p<0.05$ for all) (Table 2 and 3). It is not possible for us to identify the reasons for these differences as patients in both groups received same asthma care and asthma education. One possible explanation might be **that there were more children** with uncontrolled asthma in **the** physician group at baseline. Our study was not designed to measure other factors such as adherence, allergy sensitization, socio-economic status of families etc. and more studies are needed to understand these differences. We also noted that those who completed three-year follow-up were not significantly different than those lost to follow-up in gender, family history of asthma, smoke exposure, having a pet at home or type of provider

(physician or APN). Children who were lost to follow-up during the three-year duration of the study, were more likely to be Caucasians and with mild persistent asthma while patients with moderate or severe persistent asthma and African American and Hispanic children were more likely to continue their follow-up (Table 5). Reasons for these differences are not clear but it is possible that those with mild persistent asthma especially if they were also Caucasians were more comfortable to continue their follow-up with their primary care providers once their asthma was better controlled.

Adherence to NAEPP (EPR-3) asthma guidelines is still less than optimal^{3,4,8,9} Adoption of these clinical guidelines face many barriers in primary care settings including busy practices and the lack of time to understand and effectively implement changes.⁵ Implementing specific parts of the asthma guidelines, such as adjusting therapy based on assessment of control can improve outcomes.¹⁰ Asthma guidelines focus on evaluating severity at initiation of therapy, with further changes in therapy determined based on level of control achieved.^{3,4} Under these guidelines, control and monitoring can be specific parameters incorporated into office setting and monitored by trained individuals. Use of guidelines does not require pulmonary specialty care and can occur through primary care offices, resulting in much greater reach in the community.¹¹⁻¹² At certain steps in therapy it is reasonable/recommended to consult with a specialist especially if asthma control is inadequate, after which the PCP may assume care.^{3,4}

Asthma currently affects roughly 8-9% of all children in the United States^{1,13} and the cost to parents for children's acute health care needs is very high. Though specialty asthma clinics do improve asthma care, the majority of children will only be seen by their primary care providers without need for, or access to, a specialist.¹⁴ Primary care providers can implement basic elements of guideline based care with successful outcomes for their patients.¹⁵ In some studies, APNs have been shown to be valuable in caring for pediatric asthma related hospital admissions, offering adequate care at a lower cost to the institution.¹⁶⁻¹⁷ Increasing workload makes it more difficult for primary care providers to spend adequate time with patients, especially patients with chronic diseases such as asthma. This might be one of the reasons for increasing costs of health care, as more acute care need is required when chronic diseases are not well controlled. Data are lacking on the use of APNs for outpatient asthma care, but our current study suggest that asthma care provided by specialty trained APNs can improve asthma outcomes when the NAEPP guidelines are followed.

In a recent study, we have shown that in-office training of other members of health care team, such as APNs, registered nurses and pulmonary therapists improved the quality of asthma care in pediatric primary care practices, as measured by quality indicators based on NAEPP guidelines.¹⁸ Our group has also shown that by following asthma guidelines, quality of life of caregivers of children with asthma improve and is sustained regardless of the type of health care provider (physician or APN).¹⁹

It is well known that many facets of chronic disease management, in particular the repetitive teaching and incorporation of evolving psychosocial needs, are well addressed by nurses.²⁰ Recent systematic reviews have identified that use of clinical nurse specialists in outpatient management is cost-effective with acceptable quality of care²¹⁻²³

APNs can provide guideline-based patient care in close collaboration with physicians as a team. This model of utilizing APNs within the primary care setting can enhance a primary care office's ability to care for their entire population while ensuring evidence-based care for their asthma patients. If this model is successful in asthma, it may also be applied to other chronic diseases where guidance-based care has been established.

Limitations of our study include the use of self-reported data from parents and older children who completed their forms regarding their recall of asthma symptoms and acute care needs. Our sample size decreased over the three-year period which is a common observation in long-term studies. Even

though both patient groups had similar decrease in patients over time, impact, if any, of attrition over time on outcomes cannot be ruled out. Another limitation is that as treatment groups were not randomized there may be unmeasured differences between the groups. Differences in at least some of the asthma indicators at baseline between groups suggests that provider preference or other factors may have affected group assignment. A strength of our study is the 3-year long-term follow-up period. There is a general perception that, at least in children, the natural history of asthma suggests a reduction in disease severity over time. In our study, there were significant differences between groups in acute care needs at baseline and yet both groups improved significantly within 3-6 months and improvements were sustained over three-year follow-up period. It is unlikely that improvements are secondary to natural history as they were noted within a short period of time while patients received quality asthma care according to NAEPP guidelines.

Conclusion:

This study demonstrated that managing asthma as per NAEPP (EPR-3) guidelines does improve asthma control. Improvements in asthma control were achieved in children in both the MD and APN groups, and that significant differences in the groups may reflect baseline differences between the two groups. This indicates that APNs, working in close collaboration with physicians, can provide an important role in the management of chronic persistent asthma in children. This study was done in specialty care settings but in future this teamwork model can be applied to primary care settings.

Author Contributions

Dr. Sheikh: Contributed to the study design, study conduct, data collection, and manuscript preparation. He had full access to all of the data in the study and takes responsibility for data integrity, accuracy of the data analysis, and serves as the guarantor of the manuscript.

Judy Pitts: Contributed to the study design, study conduct, data collection, and manuscript preparation.

Nancy A Ryan-Wenger: Contributed to the study conduct, data analysis and interpretation, and manuscript preparation.

Dr. Katelyn Krivchenia and Dr. Anne May: Contributed to the data collection, and manuscript preparation.

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Conflict of Interest: The authors report no conflicts of interest and have no relevant disclosures.

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Table 1. **Demographic and clinical characteristics**

	Total (N=471)	Physician (n=217, 46%)	APN (n=254, 54%)	
	n (%)	n (%)	n (%)	p
Gender				.523
Male	283 (60.1)	127 (44.9)	156 (55.1)	
Female	188 (39.9)	90 (47.9)	98 (52.1)	
Family h/o Asthma	347 (73.7)	163 (47)	184 (53)	.511
Smoking Exposure	125 (26.5)	51 (40.8)	74 (59.2)	.168
Pet at home	258 (54.8)	114 (44.2)	144 (55.8)	.366
Race/Ethnicity				.560
Caucasian	314 (66.7)	141 (44.9)	173 (55.1)	
African American	126 (26.8)	59 (46.8)	67 (53.2)	
Hispanic	31 (6.6)	17 (54.8)	14 (45.2)	
Asthma severity				.244
Mild persistent	106 (22.5)	47 (44.3)	59 (55.7)	
Moderate persistent	324 (68.8)	146 (45.1)	178 (54.9)	
Severe persistent	41 (8.7)	24 (58.5)	17 (41.5)	
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	p
Age at first visit (years)	6.4 $\pm$ 2.4	6.4 $\pm$ 4.1	6.4 $\pm$ 4.1	.741
Age at diagnosis (years)	2.4 $\pm$ 4.1	2.5 $\pm$ 2.7	2.3 $\pm$ 2.2	.660
Duration of symptoms (years)	4.1 $\pm$ 3.5	4.2 $\pm$ 3.6	4.0 $\pm$ 3.3	.500

* Alpha level of significance $\leq .05$

Table 2. Asthma acute care indicators at baseline and across follow-up period.

	Baseline (n=471)	3 months	6 months	1 year (n=396)	2 year (n=257)	3 year (n=176)	Change in total cohort over Time	Difference between change over time between groups
	Mean ±Standard Deviation						Wald χ^2 (p) ¹	Wald χ^2 (p) ²
Mean number of Short courses of oral steroids/patient								
Total Sample	2.7 ±2.9	0.3 ±0.7	0.2 ±0.5	0.4 ±0.7	0.4 ±0.7	0.5 ±0.7	6.049 (.014)*	
Physician	3.1 ±3.2	0.3 ±0.8	0.2 ±0.5	0.4 ±0.7	0.4 ±0.7	0.5 ±0.8		
APN	2.3 ±2.6	0.2 ±0.5	0.2 ±0.5	0.4 ±0.7	0.4 ±0.6	0.4 ±0.6		
p ³	.002*	.099	.816	.651	.874	.370		10.904 ³ (.001)*
Mean number of Hospital Admissions/patient								
Total sample	0.5 ±1.0	.05 ±0.3	.05 ±0.3	.05 ±0.3	.05 ±0.2	.07 ±0.3	3.699 (.054)	
Physician	0.5 ±1.0	.07 ±0.4	.06 ±0.4	.03 ±0.2	.02 ±0.1	.06 ±0.2		
APN	0.5 ±1.1	.04 ±0.2	.04 ±0.2	.06 ±0.3	.08 ±0.3	.09 ±0.3		
p ³	.592	.354	.601	.263	.060	.403		.078 (.780)
Mean number of Emergency Room visits/patient								
Total sample	1.7 ±2.7	0.1 ±0.5	0.1 ±0.4	0.2 ±0.5	0.3 ±0.9	0.2 ±0.5	6.843 (.009)*	
Physician	1.8 ±3.1	.17 ±0.5	0.1 ±0.3	0.2 ±0.5	0.3 ±1.1	0.2 ±0.4		
APN	1.6 ±2.3	0.1 ±0.3	0.1 ±0.4	0.2 ±0.4	0.2 ±0.6	0.2 ±0.6		
p ³	.293	.191	.555	.858	.553	.484		1.460 (.227)
Mean number of Urgent care visits/patient								
Total sample	1.5 ±2.9	0.1 ±0.4	0.1 ±0.4	0.2 ±0.5	0.2 ±0.5	0.2 ±0.7	6.652 (.010)*	
Physician	1.7 ±3.4	0.1 ±0.9	0.1 ±0.5	0.2 ±0.5	0.2 ±0.1	0.3 ±0.7		
APN	1.3 ±2.5	0.1 ±0.3	0.1 ±0.3	0.1 ±0.6	0.3 ±0.7	0.2 ±0.6		
p ³	.085	.067	.668	.667	.094	.465		5.181 (.023)*
Mean number of unscheduled Primary Care visits for acute asthma/patient								
Total sample	4.4 ±5.7	0.3 ±0.7	0.2 ±0.5	0.3 ±0.7	0.4 ±0.7	0.5 ±0.8	4.520 (.034)*	
Physician	5.7 ±5.1	0.3 ±0.9	0 ±0.6	0.4 ±0.8	0.4 ±0.8	0.5 ±0.8		
APN	3.3 ±5.9	0.2 ±0.5	0 ±0.5	0.3 ±0.6	0.4 ±0.6	0.4 ±0.9		
p ³	<.001*	.015*	.387	.380	.984	.890		7.658 (.006)*

Wald χ^2 (p)¹ = significance of changes in asthma acute care indicators over time of the total sample

Wald χ^2 (p)² = significance of the difference in asthma acute care indicators between groups over time

p^3 = significance of the difference in asthma acute care indicators between groups at a single time point (at baseline, 3-month, 6-month period etc.)

* = alpha level of significance ≤ 0.05

Table 3. Asthma symptom at baseline and across follow-up period.

	Baseline (n=471)	3 months	6 months	1 year (n=396)	2 years (n=257)	3 years (N=176)	Change in total cohort over time	Difference between change over time between groups
Days/ month	Mean ±Standard Deviation						Wald χ^2 (p) ¹	Wald χ^2 (p) ²
School days missed (days/month)								
Total	5.5±7.6	0.7 ±2.3	0.6±2	0.8 ±1.7	1 ±1.9	1.5 ±2.4	5.154 (.023)*	
Physicia n	5.9 ±8.1	0.8 ±2.6	0.6 ±2.0	0.7 ±1.7	1.1 ±1.0	1.5 ±1.6		
APN	5.1 ±7.2	0.7 ±2.1	0.7 ±2.0	0.8 ±1.7	2.0 ±1.7	1.6 ±2.6		
p ³	.192	.475	.897	.622	.682	.793		2.866 (.090)
Wheezing (days/month)								
Total	10 ±9.3	2.6 ±4.4	2.6 ±5	3.1 ±4.6	3.5 ±4.7	3.3 ±3.6	11.339 (.001)*	
Physicia n	10.8 ±9.7	2.1 ±2.8	2.5 ±4.8	2.8 ±3.6	3.1 ±3.5	3.3 ±4.0		
APN	9.3 ± 8.8	3.0 ±5.4	2.8 ±5.1	3.3 ±5.4	3.8 ±5.6	2.6 ±2.8		
p ³	.083	.038	.518	.307	.230	.937		2.439 (.118)
Nighttime cough (days/month)								
Total	11.7 ±10.4	3.5 ±5.8	2.9 ±5.4	3.8 ±5.5	5.5 ±6.1	3.4 ±4.1	9.002 (.003)*	
Physicia n	12.4 ±12.3	3.3 ±5.3	2.7 ±4.8	3.6 ±4.8	5.1 ±5.0	3.7 ±5.0		
APN	11.1 ±10.5	3.6 ±6.2	3.2 ±5.9	4.0 ±6.0	5.8 ±7.0	3.1 ±2.8		
p ³	.199	.633	.420	.489	.403	.391		1.407 (.235)
Exercise limitations (days/month)								
Total	9.1 ±11.1	2.3 ±5.6	2 ±4.8	2.3 ±5	2.1 ±3.7	2.3 ±4.9	6.967 (.008)*	
Physicia n	10.4 ±11.6	2.1 ±5.0	2.1 ±5.5	2.1 ±3.8	2.0 ±3.4	2.4 ±5.7		
APN	8 ±10.6	2.5 ±6.1	1.8 ±4.1	2.5 ±5.8	2.0 ±4.0	2.1 ±4.0		
p ³	.018*	.416	.487	.505	.967	.713		3.864 (.049*)
Albuterol Use (days/month)								

Total	10 ±9.8	3.3 ±5.9	2.6 ±5	3.0 ±4.2	3.3 ±4.1	3.6 ±4	6.471 (.011)*	
Physician	10.2 ±10	3.3 ±0.6	2.1 ±3.5	2.8 ±3.8	3.2 ±4.0	3.6 ±4.1		
APN	9.8 ±9.6	3.3 ±0.6	3.1 ±6.1	3.3 ±3.6	4.1 ±4.0	3.5 ±3.4		
p^3	.626	.982	.069	.272	.675	.852		.194 (.659)

Wald $\chi^2 (p)^1$ = significance of changes in asthma acute care indicators over time of the total sample

Wald $\chi^2 (p)^2$ = significance of the difference in asthma acute care indicators between groups over time

$p3$ = significance of the difference in asthma acute care indicators between groups at a single time point (at baseline, 3-month, 6-month period etc.)

* = alpha level of significance ≤ 0.05

Table 4. Asthma Control Test scores and mean %predicted FEV1 at baseline and across follow-up period.

	Baseline	3 months	6 months	1 year	2 years	3 years	Change in total cohort over Time	Difference between change over time between groups
	Mean ±Standard Deviation (SD)						Wald χ^2 (p) ¹	Wald χ^2 (p) ²
Asthma Control Test (ACT) Score								
	n=382			n=306	n=187	n=128		
Total	15.9 ±5.7	20.3±4.9	21 ±4.7	21.2 ±4.2	21.3 ±4.5	21.9 ±4	11.577 (.001)*	
Physician	16 ±5.3	20.4 ±5.0	21.4 ±4.6	21.8 ±3.7	22.1 ±3.8	21.7 ±4.1		
APN	16 ±6	20.3 ±4.8	20.5 ±4.8	20.4 ±4.6	20.5 ±4.9	22 ±3.9		
p ³	.756	.882	.211	.027*	.022*	.708		.081 (.776)
Mean % predicted FEV1								
	n=326			n=248	n=158	n=106		
Total	93 ±17	98 ±15	96 ±15	98 ±17	9 ±15	102 ±15	.192 (.661)	
Physician	93 ±17	98 ±15	99 ±16	101 ±14	97 ±14	103 ±14		
APN	92 ±17	98 ±16	94 ±15	96 ±18	9 ±16	101 ±15		
p ³	.702	.835	.211	.146	.969	.591		1.944 (.163)

Wald χ^2 (p)¹ = significance of changes in asthma acute care indicators over time of the total sample

Wald χ^2 (p)² = significance of the difference in asthma acute care indicators between groups over time

p³ = significance of the difference in asthma acute care indicators between groups at a single time point (at baseline, 3-month, 6-month period etc.)

* = alpha level of significance ≤ 0.05

Table 5. Demographic and clinical characteristics of patients followed for the duration of the study vs. those who were lost to follow-up.

	Total (N=471)	Patients completing 3-year follow-up (n=176, 37%)	Patients lost to follow-up (n=295, 63%)	
	n (%)	n (%)	n (%)	p
Gender				.178
Male	283 (60.1)	112 (39.5)	171 (60.5)	
Female	188 (39.9)	67 (39.6)	121 (64.4)	
Family h/o Asthma	347 (73.7)	125 (36)	222 (64)	.375
Smoking Exposure	125 (26.5)	50 (40)	75 (60)	.428
Pet at home	258 (54.8)	103 (40)	155 (60)	.870
Race/Ethnicity				.016*
Caucasian	314 (66.7)	113 (36)	201 (64)	
African American	126 (26.8)	62 (49)	64 (51)	
Hispanic	31 (6.6)	16 (52)	15 (48)	
Asthma severity				<.001*
Mild persistent	106 (22.5)	10 (9.5)	96 (90.5)	
Moderate persistent	324 (68.8)	144 (44.4)	180 (55.5)	
Severe persistent	41 (8.7)	36 (88)	5 (12)	
Provider				.534
Physician	217 (46%)	80 (37)	137 (63)	
APN	(254 (54%))	99 (39)	155 (61)	
		Mean ± SD	Mean ± SD	p
Age at first visit (yrs.)	6.4 ±2.4	6.3 ±3.9	6.9 ±4.4	.012*
Age at diagnosis (yrs.)	2.4 ±4.1	2.2 ±2	2.7 ±2.9	.081
Duration of symptoms (yrs.)	4.1±3.5	3.9 ±3.5	4.3 ±3.6	.216

*Alpha level of significance ≤.05