Can A Community Evidence-based Asthma Care Program Improve Clinical Outcomes?

A Longitudinal Study

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Rationale: Asthma is associated with significant morbidity. Previous studies highlight significant variations in asthma management approaches within primary care settings where the adoption of published asthma guidelines is typically suboptimal.
Objective: To determine whether the implementation of an evidence-based asthma care program in community primary care settings leads to improved clinical outcomes in asthma patients.
Methods, Measurements, and Main Results: A community-based participatory research project was implemented at 8 primary care practices across Ontario, Canada, consisting of elements based on the Canadian Asthma Consensus Guidelines (asthma care map, program standards, management flow chart and action plan). A total of 1408 patients aged 2–55 years participated. Conditional logistic regression analyses were used to calculate the odds ratios (OR) comparing baseline to follow-up while adjusting for age, gender, socioeconomic status and other covariates. At 12-month follow-up, there were statistically significant reductions in self-reported asthma exacerbations from 77.8% to 54.5% [OR = 0.35; 95% confidence interval (CI): 0.28–0.43]; emergency room visits due to asthma from 9.9% to 5.5% (OR = 0.47; 95% CI: 0.32–0.62); school absenteeism in children from 19.9% to 10.2% (OR = 0.37; 95% CI: 0.25–0.54); productivity loss in adults from 12.0% to 10.3% (OR = 0.49; 95% CI: 0.34–0.71); uncontrolled daytime asthma symptoms from 62.4% to 41.4% (OR = 0.34; 95% CI: 0.27–0.42); and uncontrolled nighttime asthma symptoms from 46.4% to 25.4% (OR = 0.29; 95% CI: 0.23–0.37).
Conclusions: Development and implementation of a community-based primary care asthma care program led to risk reductions in exacerbations, symptoms, urgent health service use and productivity loss related to asthma.

Key Words: asthma, longitudinal studies, disease management, evidence-based medicine, primary health care

(*Med Care* 2008;46: 1257–1266)

Estimates of worldwide asthma prevalence suggest that approximately 300 million people currently have asthma. Asthma prevalence is highest in the developed world, with national estimates ranging from 10.9% in the United States to greater than 15% in the United Kingdom.[1] According to the same report, asthma prevalence in Canada is approximately 14%, though other national estimates suggest it may be slightly lower.[2,3] National and international guidelines for the management of asthma were developed to improve the diagnosis, treatment, and management of asthma, and to lessen the burden of illness.[4–12] The challenge is to implement these best practices across a range of health care settings. Recent literature suggests that current levels of asthma control are suboptimal and that provider practice falls short of evidence-based recommendations from published guidelines.[13–15]

The successful uptake of clinical guidelines such as those published for asthma is dependent upon the context of the health care setting and strategies used for dissemination and implementation.[16,17] Physician understanding of evidence-based guideline recommendations also has a significant impact on clinical outcomes for asthma. In a study of family physicians, general internists and asthma specialists, Doershug found that the most common error made by physicians—even after training to increase asthma understanding—was underestimating asthma severity, which can lead to inadequate treatment.[18] There may be a need to tailor clinical educational interventions because of contextual differences in practice settings and inherent difficulties in changing physician behavior.[18] Another issue affecting asthma management is the lack of concordance between what physicians report their practice to be and what patients report.[19] Successful asthma management depends on enhancing the adoption of guidelines into clinical practice and the uptake and application by physicians and patients.

Research suggests that combination rather than single intervention strategies targeted at patients and providers improve outcomes for asthma patients.[20–24] In addition to pharmacotherapies, written asthma action plans, asthma education

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Supported by the Ontario Ministry of Health and Long-term Care. Dr. Teresa To is supported by the Canadian Institutes of Health Research and the Ontario Ministry of Health and Long-Term Care through an Investigator Award.
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ISSN: 0025-7079/08/4612-1257

and regular follow-up are important components of optimal asthma management in both children and adults.[5,12] Previous work demonstrates that comprehensive patient interventions that include self monitoring, regular review and a written self management plan demonstrate beneficial effects including reductions in hospitalizations, emergency department (ED) or urgent care visits, number of days off work or school, and frequency of nocturnal asthma.[25–29]

Inconsistencies in beneficial outcomes reported by various studies evaluating asthma care programs (ACPs) may be partly due to differences in methodology, program implementation, and populations. For instance, many studies were limited to children and/or adolescents.[24,30–34] Weakly positive or neutral outcomes were observed in studies that focused on short-term effects of educational interventions,[35,36] compared with studies that measured effectiveness over a longer time period.[25,27,37] Well designed programs implemented in controlled hospital-based settings showed a positive impact on clinical outcomes including reduced hospitalizations and urgent health care utilization, and improved pulmonary function and patient outcomes such as quality of life.[25,27,28] Unfortunately, these favorable outcomes have not always translated to community health care settings, such as general or primary care practices (PCPs).[35,36,38,39]

Although some clinical trials demonstrate overall efficacy of ACPs in improving clinical and patient outcomes, it is important to establish the effectiveness of such programs when implemented in community settings. Our project, referred to as the Primary Care Asthma Pilot Project (PCAPP), used a participatory community-based action research approach to design, implement and evaluate a comprehensive evidence-based asthma primary care program and to identify predictors of poor patient outcomes.

METHODS

Study Design

The PCAPP used a community-based participatory approach to develop, implement and evaluate, using a pre and post design, a comprehensive evidence-based[9] ACP. This was intended to reflect "real world" effectiveness; as such, minimal changes were made to clinic management or organization. To ensure staff buy-in, clinicians (physicians, nurse practitioners, health promoters, asthma educators) and managers from participating sites, Lung Association staff and researchers met regularly (in-person, teleconference, email) to develop and review materials/resources, and plan the implementation and evaluation of the program. Patients participating in the study were assessed at 3 time points: baseline, 6-month and 12-month visits. The study methodology and materials were reviewed and approved by the Research Ethics Board at the Research Institute, The Hospital for Sick Children, Toronto, Ontario.

Intervention

The PCAPP intervention was based on asthma management standards developed by the Canadian Thoracic Society Canadian Asthma Consensus Guidelines. The program consists of 5 major components which are evidence based: (1) an asthma care map, (2) a treatment flow chart, (3) program standards, (4) a written asthma action plan, and (5) core elements of asthma education, all based on the Canadian Asthma Consensus Guidelines.[6,9,14,40,41] The program, although not based on Wagner's Chronic Disease Model,[42,43] does incorporate 3 areas outlined by Wagner. The ACP focused on improved patient self-management through asthma education and the written action plan and decision support through the dissemination of program standards and guidelines and the use of the treatment flow chart. The program also included some delivery system design through scheduled and structured patient contacts and the addition of an asthma coordinator at each site.

The asthma care map was developed by the Ontario Thoracic Society, as part of the Ontario Ministry of Health and Long-Term Care (MOHLTC) Asthma Plan of Action. The care map incorporates all elements of the Canadian Asthma Consensus Guidelines, including assessment and diagnosis; drug therapy and treatment plan; action plan; and patient education and environmental control. The care map was developed for use by a multidisciplinary team of primary healthcare providers as a template for guideline-based management. The treatment flow chart was used by physicians as a step-by-step guide to medication prescription. The program standards were used by the entire team and detailed the requirements of the program. The written asthma action plan was a patient support tool to identify their level of asthma control and to know the appropriate actions to take based on their level of control. A series of asthma education materials developed by the Ontario Lung Association and/or the project steering committee were provided to patients and families by asthma educators during visits on an individual basis determined by the patient's needs.

Intervention Primary Care Sites

The MOHLTC selected intervention sites through a letter of intent process based on ability to implement, interest in asthma care and practice size. Each site was expected to recruit at least 100 patients. The PCAPP was implemented in 8 PCPs comprising 15 satellite clinics across Ontario, Canada. These sites reside in inner-city, urban and rural communities as well as 1 Northern Aboriginal community. The PCPs included 5 Community Health Centers, a Rural Family Health Team, a Group Health Centre and an Aboriginal Access Centre. As such, the intervention sites represent a range of care settings and patient populations within Ontario. One designated asthma coordinator was assigned to each site and was responsible for implementing the ACP, performing spirometry, providing asthma education and coordinating program activities. The coordinators were either Certified Asthma Educators, respiratory therapists, or nurses with experience in asthma education. The addition of an asthma coordinator was the only structural change made at the participating sites.

Training Activities

Before implementation, mandatory 3-hour training workshops were held for clinic personnel at all participating practices regarding the use of all ACP components and to get feedback. Additional training sessions were given to participating health care providers on the use and interpretation of spirometry results. Two site visits were made by the research team to assess the understanding and uptake of the ACP and to encourage adherence and uniformity of implementation. The first visit was conducted within the 3-month period preceding implementation and the second visit occurred within the first year postimplementation.

Sampling, Recruitment and Data Collection

Assessment and recruitment were conducted by the PCAPP asthma coordinator who approached all patients identified with physician-diagnosed mild to moderate asthma for study participation. All asthma patients seen at participating sites received the intervention, irrespective of research study consent. Informed consent was obtained from patients 16 years of age or older; patients between the ages of 7–15 years provided patient assent while their parent or guardian provided proxy consent. For patients under 7 years of age, parental or guardian consent alone was obtained. The asthma health questionnaire, administered at patient interviews to those who consented, included information on self-reported health status, signs and symptoms, health services use, environmental triggers, asthma education, smoking status, patient demographics and quality of life. The questionnaire was piloted for face and content validity.

ANALYSIS

Outcome Variables

Four primary clinical outcome measures were included in the analysis: (1) asthma exacerbations, (2) asthma-related acute health services use, (3) productivity loss due to asthma, and (4) asthma symptom control. All outcome variables were self-reported by patients or caregivers; patient report has been shown to be a reliable proxy measure of outcomes.[44] Asthma exacerbations were measured by attacks in the previous 6 months (characterized by the sudden worsening of symptoms that resulted in difficulty breathing and often required taking extra medicine to relieve asthma symptoms). Asthma related acute health services use was measured by ED visits, hospitalizations or urgent care visits (physician, walk-in clinic or urgent care center) due to asthma in the previous 6 months. Productivity loss was measured by school absenteeism or work missed in the previous 4 weeks due to asthma. Asthma symptom control was measured by asthma-related symptoms. Lack of daytime symptom control was defined by asthma symptoms more than 3 times per week (ie, wheezing, shortness of breath, chest tightness or cough) in the last 4 weeks. Lack of nighttime control was defined by one or more times per week of nighttime symptoms in each of the last 4 weeks. For the analysis, outcome variables were dichotomized into binary outcome measures (yes/no). Measures of day and nighttime symptom control were also used as a proxy measure of severity of asthma and were included as covariates when examining other outcome measures. Outcome measures collected at baseline, 6 months, and 12 months were compared. As the results comparing baseline to 6 months did not differ significantly from the comparisons at 12 months, only the latter were detailed in the tables that assessed change over time.

Covariates

Baseline demographic information was collected from patients and included date of birth, gender, level of education, household income, household size and whether patients had a drug benefit plan to pay for asthma medications. Using household income and size, a proxy measure of socioeconomic status (SES) was derived. A family of 4 or more with an annual income of less than $40,000 (Canadian dollars) was defined as low SES based on the 2002 before tax Low Income Cut-offs as calculated by Statistics Canada.[45]

Information on asthma self-management factors including: smoking, peak flow meter use, routine visits to health care providers for asthma, asthma medication use, and asthma education accessed outside of the PCAPP was collected from patients. Environmental assessment for triggers (eg, presence of furry animals, second-hand smoke and carpets) and environmental control practices (eg, using airtight pillow and mattress covers), were documented. Data were also collected on whether patients had received a written asthma action plan outside of the study, ever had spirometry and/or received demonstrations on the use of medication. These covariates were used to control for variations in self and clinical care.

Statistical Analysis

Baseline characteristics of study participants, including demographics, asthma status, clinical and self-management were described using proportions and means as appropriate. Changes in clinical outcomes from baseline to the 12-month follow-up period were described using crude odds ratio (OR) estimates and corresponding 95% confidence intervals (CI) based on conditional logistic regression methods.[46] Given a sample size of 1000 participants with 12-month follow-up, the study was powered at 80% to detect a change of 26% from a baseline event rate of 13% for ED visits or a 7% change from a baseline event rate of 76% for asthma exacerbations.

Multivariable longitudinal analysis using binomial regression models with generalized estimating equations was conducted to model the fixed effects of covariates on clinical outcomes at 6- and 12-month follow-ups, adjusting for baseline covariates and accounting for repeated measures on patients. Each outcome was modeled separately using all identified covariates and manual stepwise backwards elimination to identify significant predictors of poor outcomes. All models were adjusted for age, gender and SES and tested for differences associated with baseline clinical management and site of care using an urban, rural, and inner-city categorization. All analyses were stratified by adults and children. The Statistical Analysis Systems software, version 9.1[47] was used to conduct all analyses.

RESULTS

Study Population

Figure 1 describes study recruitment, inclusion and exclusion criteria. Based on site estimates, 1950 patients were identified for study participation of which 1449 (74.3%) responded and 1408 (72.2%) met eligibility criteria and were recruited between January 2003 and March 2005. Of these, 70.0% (986) and 72.2% (1016) completed the 6- and 12-month follow-ups, respectively.

Table 1 describes characteristics of the study population at baseline, stratified by adults and children (under

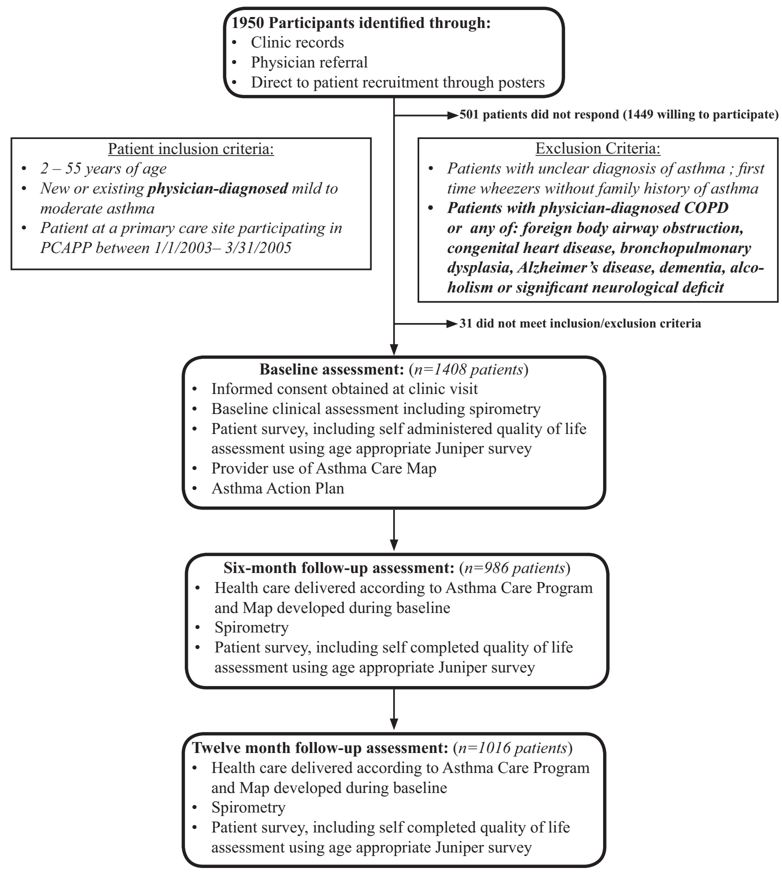

FIGURE 1. Recruitment process. Eight primary care practices (rural, urban, and inner city locations) were selected by the MOHLTC and participated in the PCAPP. Practice types included 5 community health centers, 1 rural health team, 1 group health center, and 1 aboriginal access center.

18 years of age). The mean age of adults and children were 38.8 years and 9.7 years, respectively. Females comprised 44.9% of the pediatric population and 75.9% of the adult population. Patients were recruited from urban, rural, and inner-city sites, 28.7%, 33.1% and 38.2%, respectively. Slightly more children had low SES than adults (13.2% in children vs. 9.1% in adults). Patients' activity level was self-rated on a comparative scale ranging from "much more active" to "much less active" than others their own age. The last 2 categories, moderately and much less active were combined which reflect individuals who consider themselves less active than others their own age. Compared with children, adults were less active than others their age (19.0% and 39.6%, respectively). Similarly, patients were asked to rate their health status on a 5-category scale from excellent to poor. Adults were more likely to rank their health as fair or poor (the lowest 2 ratings) as compared with children (15.8% and 31.4%, respectively). In general, adults also reported more wheeze, shortness of breath, chest tightness and symptoms upon waking than children.

Almost twice as many adults as children (7 years and older) reported ever having spirometry at baseline (67.4% vs. 38.4%) though a similar proportion reported regular use of a peak flow meter to monitor their asthma. Slightly more than 1 in 3 participants (36.5%) received asthma education prior to that provided by the program and this did not differ by patient age group. At baseline, children were less likely than adults to experience some self-management strategies (weekly washing of linens in hot water) but were equally likely to use airtight pillow or mattress covers (Table 1).

The program was intended to improve diagnosis and clinical management of asthma using pulmonary function tests (spirometry and regular peak flow monitoring) and self management through the use of action plans and increased access to asthma education. Table 2 shows the results of unadjusted conditional logistic regression analysis on these program parameters. Among participants with full follow-up (12 months), adults and children showed marked improvements in pulmonary function testing and access to personalized asthma action plans. These improvements were statistically significant, however so was the decline among adults and children in access to asthma education materials outside of those provided by the study.

Outcomes Measures

Using unadjusted conditional logistic regressions, Table 3 shows that at 12-month follow-up, all clinical outcomes were significantly improved from baseline in both children and adults. Table 4 shows results adjusted for covariates. As the results comparing baseline to 6 months did not differ significantly from the 12-month comparisons, only the latter were detailed in Table 3. The following are the results for each clinical outcome considered.

TABLE 1. Baseline Characteristics of Study Population

Characteristic	Children N = 642		Adults N = 766		Total N = 1408	
	No.	(%)	No.	(%)	No.	(%)
Demographics						
Mean age (SD) years	9.69	(4.19)	38.83	(10.56)	25.54	(16.71)
Female sex	288	(44.86)	581	(75.85)	869	(61.72)
Education ≥college education	NA		432	(56.54)	432	(56.54)
Low socioeconomic status (SES)	85	(13.24)	70	(9.14)	155	(11.01)
Without a drug benefits plan	156	(25.04)	188	(24.90)	344	(24.96)
Care site location						
Urban	236	(36.76)	168	(21.93)	404	(28.69)
Rural	194	(30.22)	272	(35.51)	466	(33.10)
Inner city	212	(33.02)	326	(42.56)	538	(38.21)
Health status						
Fair to poor health rating	100	(15.82)	237	(31.43)	337	(24.31)
Less active	122	(19.00)	303	(39.61)	425	(30.21)
Asthma control (in last 4 wks)						
Wheeze	341	(53.12)	545	(71.24)	886	(62.97)
Shortness of breath	382	(59.50)	613	(80.03)	995	(70.67)
Chest tightness	268	(41.88)	553	(72.29)	821	(58.43)
Cough	498	(77.81)	578	(75.56)	1076	(76.58)
Any daytime symptoms	565	(88.01)	715	(93.34)	1280	(90.91)
Any uncontrolled daytime symptoms (≥3×/wk)	383	(59.66)	521	(68.02)	904	(64.20)
Any nighttime symptoms	383	(59.94)	498	(65.53)	881	(62.97)
Any uncontrolled nighttime symptoms (≥1/wk)	278	(43.51)	373	(49.08)	651	(46.53)
Awaken during sleep	72	(11.21)	86	(11.23)	158	(11.22)
Symptoms upon waking	52	(8.10)	140	(18.28)	192	(13.64)
Smoking status						
Current smokers (≥10 yrs of age only)	15	(5.08)	241	(31.54)	256	(24.17)
Exposure to second hand smoke	215	(34.02)	377	(50.00)	592	(42.71)
Medication use (last 6 mos)*						
Reliever use	528	(82.24)	658	(85.90)	1186	(84.23)
Preventer use	481	(74.92)	544	(71.02)	1025	(72.80)
Asthma management (clinical and self)						
Ever spirometry†	166	(38.43)	493	(67.44)	666	(55.22)
Action plan provided by doctor outside of ACP	73	(11.62)	112	(14.87)	185	(13.40)
Received asthma education in the last 6 mos outside of PCAPP	226	(35.48)	286	(37.34)	512	(36.49)
Use a peak flow meter to monitor asthma regularly	137	(21.70)	174	(22.96)	311	(22.39)
Washed bedcovers in hot water weekly	220	(34.27)	478	(62.40)	698	(49.57)
Used airtight pillow covers	60	(9.35)	103	(13.45)	163	(11.58)
Used airtight mattress covers	60	(9.35)	101	(13.19)	161	(11.43)
Carpeting in bedroom	185	(28.82)	356	(46.48)	541	(38.42)

All percentages are adjusted for missing data.
*Reliever and preventer medications refer to those outlined in the Canadian Consensus Guidelines.[6]
†Spirometry data limited to children 7 years and older (n = 432).

Asthma Exacerbations

Table 3 shows the percentage of participants (adults and children) who experienced one or more asthma exacerbations in the last 6 months. Overall, the proportion of participants who experienced one or more asthma exacerbations remained high at 12 months (54.5%). However, there was a statistically significant relative reduction of 29.9% from a baseline high of 77.8% (OR = 0.35; 95% CI: 0.28–0.43; $P < 0.0001$). The multivariable regression analysis (Table 4) shows that after adjusting for age, sex, SES, baseline clinical and self-management, site group, and repeated measures at the 2 follow-ups, previous asthma exacerbations (in the last 6 months as reported at baseline) remained the most significant predictor for asthma exacerbation at 12-month follow-up in both children (OR = 2.43; 95% CI: 1.67–3.52; $P < 0.0001$) and adults (OR = 3.37; 95% CI: 2.25–5.05; $P < 0.0001$) participating in the PCAPP.

TABLE 2. Program Parameters at Baseline and 12-Month Follow-Up Among Patients With 12-Month Follow-Up

	Children (Max N = 463)				Adults (Max N = 551)				Total (Max N = 1014)			
	Baseline	12-Mo	Change		Baseline	12-Mo	Change		Baseline	12-Mo	Change	
Program Measure	% (N)	% (N)	OR*	(95% CI)	% (N)	% (N)	OR*	(95% CI)	% (N)	% (N)	OR*	(95% CI)
Not counting materials received at your baseline visit for this study, have you been given a personal asthma self-management plan or action plan?	12.14 (55)	26.02 (115)	2.34	(1.62–3.38)§	17.29 (93)	31.87 (167)	2.46	(1.77–3.42)§	14.93 (148)	29.19 (282)	2.41	(1.88–3.07)§
Do you use a peak flow meter at home or in the doctor's office to regularly monitor your asthma?	20.93 (95)	36.20 (164)	2.52	(1.78–3.58)§	23.35 (127)	46.52 (254)	4.44	(3.10–6.38)§	22.24 (222)	41.84 (418)	3.39	(2.64–4.35)§
Have you had spirometry done before?	37.91 (127)	87.79 (302)	29.83	(13.23–67.30)§	366 (70.11)	94.81 (512)	14.36	(7.80–26.47)§	57.53 (493)	92.08 (814)	19.82	(12.18–32.27)§
In the last 6 mos, not counting today or your baseline visit for this study, have you received any asthma education?	36.38 (167)	20.04 (92)	0.42	(0.30–0.58)§	40.11 (221)	24.73 (136)	0.44	(0.33–0.58)§	38.42 (388)	22.60 (228)	0.43	(0.35–0.53)§

*OR, crude odds ratio based on conditional logistic regressions.
†$P < 0.05$.
‡$P < 0.001$.
§$P < 0.0001$.

TABLE 3. Distribution of Outcome Measures at Baseline and 12-Month Follow-Up Among Patients with 12-Month Follow-Up

	Children (Max N = 463)				Adults (Max N = 551)				Total (Max N = 1014)			
	Baseline	12-Mo	Change		Baseline	12-Mo	Change		Baseline	12-Mo	Change	
Outcome Measures	% (N)	% (N)	OR*	(95% CI)	% (N)	% (N)	OR*	(95% CI)	% (N)	% (N)	OR*	(95% CI)
Acute episodes (last 6 mos)												
Asthma exacerbations	77.45 (340)	51.24 (227)	0.25	(0.18–0.36)§	78.05 (384)	57.40 (283)	0.44	(0.33–0.59)§	77.77 (724)	54.49 (510)	0.35	(0.28–0.43)§
Health services use (last 6 mos)												
Any urgent or walk-in clinic visits	13.45 (62)	6.91 (32)	0.42	(0.26–0.68)‡	12.91 (71)	7.44 (41)	0.48	(0.30–0.74)†	13.16 (133)	7.20 (73)	0.45	(0.32–0.62)§
ED visits	13.42 (62)	3.89 (18)	0.18	(0.09–0.36)§	6.90 (38)	6.90 (38)	1.00	(0.60–1.66)	9.87 (100)	5.52 (56)	0.47	(0.32–0.69)§
Hospitalizations	1.08 (5)	1.3 (1.30)	1.00	(0.29–3.45)	0.91 (5)	0.54 (3)	0.60	(0.14–2.51)	0.99 (10)	0.89 (9)	0.80	(0.32–2.03)
Loss of productivity (last 4 wks)												
Missed school or work	19.91 (88)	10.2 (47)	0.37	(0.25–0.54)	12.04 (59)	10.28 (52)	0.49	(0.34–0.71)‡	15.77 (147)	10.24 (99)	0.43	(0.33–0.56)§
Symptom control (last 4 wks)												
Any uncontrolled daytime symptoms	57.67 (267)	30.67 (142)	0.07	(0.04–0.11)§	66.42 (366)	50.45 (278)	0.05	(0.03–0.09)§	62.43 (633)	41.42 (420)	0.34	(0.27–0.42)§
Any uncontrolled nighttime symptoms	43.26 (199)	19.78 (90)	0.28	(0.19–0.39)§	48.99 (267)	30.09 (164)	0.31	(0.22–0.43)§	46.37 (466)	25.40 (254)	0.29	(0.23–0.37)§

*OR, crude odds ratio based on conditional logistic regressions.
†$P < 0.05$.
‡$P < 0.001$.
§$P < 0.0001$.

TABLE 4. Adjusted Multivariable Regression Models Predicting Adverse Asthma Outcomes

Covariates¶ (in descending order of the combined OR)	Children		Adults		Total	
	OR*	(95% CI)	OR*	(95% CI)	OR*	(95% CI)
Outcome: Acute Episodes						
Baseline self-reported asthma exacerbations	2.43	(1.67–3.52)§	3.37	(2.25–5.05)§	2.89	(2.19–3.82)§
Use of preventer at baseline	2.08	(1.41–3.07)‡	—	—	1.58	(1.22–2.04)‡
Symptoms upon waking	—	—	—	—	1.49	(1.03–2.14)†
Exposure to second hand smoke	—	—	1.66	(1.20–2.28)†	1.30	(1.03–1.64)†
Any uncontrolled daytime symptoms	—	—	—	—	1.29	(1.03–1.63)†
Rural site	1.70	(1.20–2.42)†	1.62	(1.18–2.23)†	1.56	(1.23–1.96)‡
Any uncontrolled nighttime symptoms	—	—	1.58	(1.15–2.18)†	—	—
Outcome: Health Services Use—ED Visits						
Baseline history of ED visits	3.23	(1.45–7.15)†	—	—	3.80	(2.15–6.74)§
Any uncontrolled daytime symptoms	3.43	(1.39–8.46)†	—	—	2.77	(1.50–5.12)†
Have an action plan provided by doctor outside of ACP	—	—	3.56	(1.77–7.19)‡	2.25	(1.22–4.18)†
Symptoms upon waking	—	—	2.67	(1.33–5.37)†	2.11	(1.23–3.64)†
Awaken during sleep	—	—	—	—	2.00	(1.15–3.49)†
Use a peak flow meter to monitor asthma on a regular basis	—	—	0.44	(0.20–0.96)†	0.44	(0.23–0.83)†
Any routine visits in the last 6 mos	1.42	(1.27–13.52)†	—	—	—	—
Any uncontrolled nighttime symptoms	—	—	2.72	(1.43–5.17)†	—	—
Outcome: Productivity Loss						
Use of preventer at baseline	2.49	(1.26–4.91)†	—	—	2.39	(1.53–3.72)‡
Missed school or work at baseline	—	—	2.11	(1.15–3.87)†	1.73	(1.17–2.55)†
Inner city site	—	—	2.39	(1.38–4.13)†	1.47	(1.05–2.05)†
Any uncontrolled nighttime symptoms	—	—	2.17	(1.23–3.81)†	—	—
Have an action plan provided by doctor outside of ACP	—	—	2.25	(1.27–3.97)†	—	—
With a drug benefits plan	1.60	(1.02–2.50)†	—	—	—	—
Outcome: Asthma Daytime Symptoms						
Any uncontrolled daytime symptoms	1.78	(1.31–2.42)‡	2.00	(1.43–2.78)§	1.70	(1.33–2.17)§
Symptoms upon waking	2.57	(1.45–4.56)†	—	—	1.62	(1.17–2.23)†
Any uncontrolled nighttime symptoms	—	—	1.72	(1.26–2.35)§	1.56	(1.24–1.96)‡
Exposure to second hand smoke	—	—	1.89	(1.43–2.50)§	1.52	(1.23–1.88)‡
Any routine visits in the last 6 mos	—	—	—	—	1.25	(1.00–1.56)†
Outcome: Asthma Nighttime Symptoms						
Any uncontrolled nighttime symptoms	2.19	(1.54–3.11)§	3.38	(2.37–4.81)§	2.79	(2.16–3.60)§
Symptoms upon waking	1.81	(1.02–3.21)†	1.49	(1.00–2.23)†	1.51	(1.09–2.09)†
Any uncontrolled daytime symptoms	—	—	1.58	(1.05–2.36)†	—	—
Washed bedcovers in hot water weekly	—	—	1.62	(1.17–2.24)†	—	—

Only variables with $P < 0.05$ were included in the final model and all models were adjusted for age and sex.
*OR, adjusted odds ratio based on multivariable logistic regression for fixed effects and repeated measures.
†$P < 0.05$.
‡$P < 0.001$.
§$P < 0.0001$.
¶Initial models included measures of: demographics (age, gender, low socioeconomic status, care site location, drug benefits), symptoms (presence of uncontrolled daytime symptoms, presence of uncontrolled nighttime symptoms), clinical care (preventer use, spirometry, accessed routine care, had an action plan outside of program, had asthma education outside of program) and self management (used peakflow to regularly monitor asthma, second hand smoke, regular washing of bedcovers in hot water, airtight pillow and mattress covers, and carpeting in bedrooms).

Asthma Related Acute Health Services Use

Measures of acute health services use included ED visits, hospital admissions and unscheduled visits to family doctors or to walk-in clinics in the last 6 months. Table 3 shows that at baseline, 9.9% of patients reported ED visits in the last 6 months, which declined significantly to 5.5% at 12 months (OR = 0.47; 95% CI: 0.32–0.69; $P < 0.0001$). Although children had a higher baseline reported ED visit rate than adults, (13.4% vs. 6.9%), the over 70% relative reduction at 12 months in this group was highly significant (OR = 0.18; 95% CI: 0.09–0.36, $P < 0.0001$). Hospitalization rates due to asthma at baseline were low for both children (1.1%) and adults (0.9%) and did not show any significant change during the follow-up period. When all unscheduled outpatient health services visits were combined (ie, unscheduled visits to family doctors or to walk-in clinics), there was an overall relative reduction of use by 45.3% from 13.2% at baseline to 7.2% at 12 months (OR = 0.45; 95% CI: 0.32–0.62; $P < 0.0001$) for study participants. The multivariable regression analysis (Table 4) shows that after adjusting for covariates, a history of ED visits (OR = 3.23; 95% CI: 1.45–7.15; $P = 0.0039$) and uncontrolled daytime symptoms (OR = 3.43; 95% CI: 1.39–8.46; $P = 0.0074$) were the most significant predictors of the risk of ED visits during follow-ups in children. In adults, significant clinical predictors of the risk of ED visits during follow-ups included having uncontrolled nighttime symptoms (OR = 2.72; 95% CI: 1.43–5.17; $P = 0.0023$) and having symptoms upon waking (OR = 2.67; 95% CI: 1.33–5.37; $P = 0.0056$).

Loss of Productivity Due to Asthma

Productivity loss in the last 4 weeks was defined as any days missed at work or any days absent from school. Table 3 shows a decline in reported productivity loss among adults from 12.0% at baseline to 10.3% at 12 months, representing a 14.5% relative reduction (OR = 0.49; 95% CI: 0.34–0.71; $P < 0.001$). At baseline, relative to adults, children reported a higher level of productivity loss due to school absenteeism (19.9% at baseline to 10.2% at 12 months). Over the 12-month study period, school absenteeism was reduced by 48.8% (OR = 0.37; 95% CI: 0.25–0.54; $P < 0.0001$). Table 4 shows that after adjusting for other covariates, self-reported work or school absenteeism at baseline was associated with absenteeism reported at follow-ups (OR = 1.73; 95% CI: 1.17–2.55; $P = 0.0055$).

Asthma Symptoms Control

Table 3 shows that the frequency of uncontrolled daytime asthma symptoms was more prevalent than uncontrolled nighttime symptoms in children and adults. During the study, the frequency of uncontrolled asthma symptoms declined significantly. Overall, there was a 33.7% relative reduction (OR = 0.34; 95% CI: 0.27–0.42; $P < 0.0001$) in daytime asthma symptoms and a 45.2% relative reduction (OR = 0.29; 95% CI: 0.23–0.37; $P < 0.0001$) in nighttime asthma symptoms. Table 4 shows that after adjusting for other covariates, self-reported uncontrolled asthma symptoms at baseline were associated with higher risks of uncontrolled asthma symptoms at follow-ups in both children and adults.

DISCUSSION

This study assessed the impact of the PCAPP on using clinical outcomes at 1-year, including exacerbations and health service utilization variables. Overall, the ACP led to better control of asthma symptoms and reductions in asthma exacerbations, health service utilization and productivity loss for adults and children. Similar to other studies that implemented strategies to improve asthma management in PCPs,[24,35] we also showed a decrease in the number of patients experiencing uncontrolled daytime asthma symptoms or who were awakened at night due to asthma.

To our knowledge, this is the largest comprehensive evidence-based, community, primary ACP implemented and evaluated. Our results showed improvements in clinical outcomes at 1 year for both children and adults. Many studies seeking to improve asthma outcomes based on consensus guidelines focus on improving one aspect of clinical management such as introducing asthma education[25,48] or implementing an action plan.[22,26] Although these studies show the benefits of introducing asthma management strategies based on national guidelines, few published studies have shown the benefits of implementing a comprehensive program such as the PCAPP. Of those, most have examined the impact of an ACP in a controlled clinical trial setting,[29,30,49] making significant contributions to the literature. However, it is equally important to determine if the results achieved in a well-controlled clinical trial setting are reproducible in the "real world."

Similar to other studies, our study did not demonstrate a reduction in hospitalization due to asthma from baseline to the 12-month follow-up.[27,41] The rates of hospitalization due to asthma were low at all time points (0.9% at both baseline and at 12 months). This was likely due to the inclusion criteria being restricted to patients with mild to moderate asthma. This finding is similar to the multicenter outpatient clinical trial that excluded patients with severe asthma and as a consequence found few hospital admissions in both their intervention and control groups.[27] Studies conducted at hospital-based practices[28] tend to include patients with more severe asthma, major comorbidities, and who have a history of hospital admissions,[50] thus suggesting differences in patient populations seen in primary and acute/hospital settings.

Our study has some limitations. The lack of a proper control group in the prepost design makes it difficult to assign 'cause' to the changes seen in outcomes among PCAPP participants. These may be due to the program or to some other changes that were naturally occurring at the time. To our knowledge, there were no changes to primary care practice or guidelines during the course of the study, but it is impossible to rule out unmeasured and uncontrolled factors. However, the 'real world' setting that was used and the improvements that were seen in asthma care suggest a highly plausible association between the change in adverse outcomes and program implementation.

Another limitation of the study was the selection of study sites which was not random but by invitation. Study sites differed in location (urban, rural, inner-city) and type of practice and were reflective and inclusive of the various types of PCPs across Ontario. To account for site differences that may impact the clinical outcomes of interest; site location was included in our regression analyses. It is not, however, possible to account statistically for a potentially higher level of commitment to the PCAPP by study staff. The role out of the project on a large scale across the province will provide a better picture of the variation in implementation and outcomes.

Although previous reviews of clinical trials have confirmed that a comprehensive coordinated intervention leads to improvement in patient management and outcomes, few published studies outside the controlled clinical trial environment exist in a primary care setting.[31] To our knowledge, the PCAPP is the first longitudinal outcome study that examined the impact of an evidence-based ACP implemented on a large scale within community primary care settings in Canada. Results indicated that the evidence-based ACP led to significant reductions in the odds of asthma exacerbations, ED visits, daytime and nighttime asthma-related symptoms, and school and work absenteeism at 12-month post implementation. Our study generated quantifiable estimates of the impacts of a comprehensive community-based primary care asthma intervention program in improving clinical outcomes. Future research can consider studying the cost-effectiveness, sustainability or impact on quality of life of an ACP such as the PCAPP.

ACKNOWLEDGMENTS

The authors acknowledge the following members of the Primary Care Asthma Pilot Project Steering Committee who provided guidance to the project and to all the participating sites and their respective asthma coordinators: Chair—Itamar Tamari, Coordinators—Janice Belanger at Sault Ste. Marie Group Health Centre; Karen Jones at North Lanark, Merrickville and Country Roads Community Health Centers; Christine Laver at Somerset West Community Health Centre; Steve Mulholland at North Hamilton Community Health Centre; Kathleen Schlifer at South Riverdale and East End Community Health Centers; Oxana Latycheva at LAMP and Stonegate Community Health Centers; Lynn Wilson at Rural Kingston Family Health Network; Sharon Strachan at the Gizhewwaadiziwin Aboriginal Access Centre; and Flemingdon Community Health Centre as the control site. The authors also thank all the patients who participated in this study.

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