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ORIGINAL ARTICLE

The Regional Asthma Disease Management Program (RADMP) for low income underserved children in rural western North Carolina: a National Asthma Control Initiative Demonstration Project

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Abstract

Background: A substantial proportion of low-income children with asthma living in rural western North Carolina have suboptimal asthma management. To address the needs of these underserved children, we developed and implemented the Regional Asthma Disease Management Program (RADMP); RADMP was selected as one of 13 demonstration projects for the National Asthma Control Initiative (NACI). *Methods*: This observational intervention was conducted from 2009 to 2011 in 20 rural counties and the Eastern Band Cherokee Indian Reservation in western North Carolina. Community and individual intervention components included asthma education in-services and environmental assessments/remediation. The individual intervention also included clinical assessment and management. *Results*: Environmental remediation was conducted in 13 childcare facilities and 50 homes; over 259 administrative staff received asthma education. Fifty children with mild to severe persistent asthma were followed for up to 2 years; 76% were enrolled in Medicaid. From 12-month pre-intervention to 12-month post-intervention, the total number of asthma-related emergency department (ED) visits decreased from 158 to 4 and hospital admissions from 62 to 1 ($p < 0.0001$). From baseline to intervention completion, lung function FVC, FEV1, FEF 25–75 increased by 7.2%, 13.2% and 21.1%, respectively (all $p < 0.001$), and average school absences dropped from 17 to 8.8 days. Healthcare cost avoided 12 months post-intervention were approximately $882 021. *Conclusion*: The RADMP program resulted in decreased ED visits, hospitalizations, school absences and improved lung function and eNO. This was the first NACI demonstration project to show substantial improvements in healthcare utilization and clinical outcomes among rural asthmatic children.

Keywords

Education, management/control, morbidity and mortality, pediatrics, treatment

History

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Introduction

One in five children with asthma in the USA visited the emergency department (ED) for asthma annually 2007–2009 [1]. Poverty, psychosocial problems and poor medical care are major barriers to patients receiving regular review of their asthma, but research suggests that patient-centered approaches have the potential to decrease these barriers [2]. Yet as noted by the Guildelines Implementation Panel (GIP) report with proper patient-centered asthma management, most ED visits, hospital admissions and asthma deaths are completely preventable [3]. A patient-centered approach to asthma management has been linked to improved patient health outcomes [4].

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In 2008, the National Asthma Education and Prevention Program (NAEPP) created the National Asthma Control Initiative (NACI) [5]; NACI's programmatic goals include putting asthma guidelines into practice in local settings. In 2009, NACI/NAEPP/NHLBI funded 13 asthma demonstration projects [5]. These projects primarily focused on strengthening linkages among providers, clinics and institutions; their goal was to ''promote programs and policies that support asthma-friendly environments'' [5]. Eleven of the 13 projects were targeted to urban environments. However, the Regional Asthma Disease Management Program (RADMP), located in western North Carolina, was one of two, among the 13 NACI demonstration projects, that focused on rural asthma. Specifically, the RADMP addressed health disparities among underserved children with asthma; children and families were given care and education in their local settings – homes, childcare centers and schools (NACI).

One out of every four children in western North Carolina was living in poverty in 2009 [6]. Over 56% of children cared

for in the regional hospital system were Medicaid recipients; at least 7% were in the North Carolina Health Choice program that provides low cost health insurance, and another 37% had no insurance at all. While the average NC state asthma hospital discharge rate for children ages 0–14 in 2012 was 163.7 per 100 000 population, two Western North Carolina counties, Graham and Swain County, had asthma hospitalization rates of 263.7 per 100,000 and 450.1 per 100,000, respectively [7]. Similarly, in 2008 the Asthma ED rate per 1000 population in several other Western counties (Buncombe 15.0, Haywood 14.8, Swain 12.3) was higher than the state average of 9.4 asthma ED visits per 1000 [8].

The RADMP used a multidisciplinary, multiagency and multifaceted approach including education along with environmental assessments and remediation at the community and individual level. In addition, clinical assessment and management was provided at the individual level. The RADMP program addressed health disparities in underserved and impoverished children suffering from asthma in rural Western North Carolina [9]. We report here the results of an intensive community and individual level intervention for low income and underserved children with sub-optimally managed asthma.

Methods

Study design

This demonstration intervention project was designed to be consistent with the GIP recommendations (education, environmental assessment/remediation and clinical assessment/management); they were implemented at the community and/or individual levels (Table 1). The community level focused on institutions, organizations and networks, and their staff, including school administrators, teachers, parents; the individual level focused on rural uninsured/underinsured children from 3 to 12 years of age, and their families.

In this study, data were collected at three time points: baseline, defined as the 12 months before enrollment into the program; during the intervention, defined as enrollment through the last visit in September 2011; and post-intervention defined as the 12 months following completion of the intervention. Community asthma education in-services and individual clinical level asthma assessment and management were conducted by one full time and one 16-h/week respiratory therapist who were well connected in the 20 county regions and Qualla Boundary. The respiratory therapists collaborated and developed partnerships with administrative staff in western North Carolina school systems and child centers and the Cherokee Indian Hospital Authority. In addition, for the environmental assessments/remediation, partnerships with the NC Department of Environmental and Natural Resources (DENR), Children's Environmental Health Branch and the NC Division of Public Health were established. Other collaborators included WNC primary care providers, satellite clinics, sub-specialists, school nurses, social workers and case managers.

Table 1. Areas of GIP focus/intervention.

Level	Asthma education	Environmental assessment/ remediation	Clinical assessment/ management
Individual	x	x	x
Community	x	x	

Community level intervention

Education in schools and childcare centers. The 11 asthma in-service sites were selected to be geographically distributed among the 20 counties in Western Carolina so that educators, staff and parents from all counties had an opportunity to attend. Childcare sites were located in 12 counties of the region and the Qualla Boundary (Eastern Cherokee Indian Reservation).

A total of 11 asthma education workshops (''in-services''), in partnership with the NC Asthma Program, were conducted during the project period. Each workshop lasted approximately 2–3 h. The North Carolina Asthma Education Curriculum for Child Care Providers was used; the curriculum included educational handouts, a power point presentation, commitments to be smoke-free and pledges to create an ''asthma friendly environment''.

The education provided at each workshop focused on asthma triggers and solutions. Asthma triggers included environmental tobacco smoke exposure, pest infestation, dust mite allergens, carbon monoxide and mold related to water damage from leaks (roofs, kitchen and bathroom). Education materials on asthma triggers, medications and self-management were provided for participants to take home. These included EPA booklets such as ''Indoor Air Quality and Student Performance (EPA-402-K-03-006)'' as well as American Lung Association booklets (listed in Supplementary materials, Table 1).

An asthma knowledge questionnaire was administered to the parents, caregivers, teachers, and students before and after the workshop. Participants were given a commitment form to sign, stating that they would make every effort to reduce the levels of irritants such as mold and carbon monoxide in their homes and organizations and provide smoke-free environments around children. Self-identified smokers and those interested in obtaining more information for family members and friends were referred to the regional hospital's Nicotine Dependence Program and the NC QuitLine.

Environmental assessments/remediation. In partnership with the NC Division of Public Health, the RADMP team conducted environmental assessments in the 11 childcare sites selected for asthma in-services plus 3 additional childcare sites. These asthma in-service/environmental assessment locations in 12 counties and the Qualla Boundary were in relatively close proximity to the 8 other Western counties participating in the demonstration project/intervention. Several of the childcare center sites were located on the grounds of elementary, middle or high schools in the region, often in portable trailers. Staff, students, parents and caregivers affiliated with these locations participated in educational workshops.

Certified Healthy Home Specialists conducted thorough environmental assessments, which took approximately 2–4 h each. The environmental assessments determined the presence of irritants such as mold, carbon monoxide, tobacco

smoke exposure and other environmental triggers of asthma-related symptoms. Appropriate referrals and follow-up remediation were conducted for all sites with identified irritants.

Individual level intervention-clinical asthma assessment, management, and environmental remediation ($n = 50$)

Children with asthma were recruited through primary care physicians (PCPs), subspecialists, hospitals, emergency departments, satellite clinics (Graham County, Emma Clinic), school nurses and social workers in the rural 20 county Western North Carolina region. Although no child was refused participation in RADMP based on ethnicity, a predominant focus of the program was outreach to underserved, impoverished and uninsured/underinsured children between 3 and 12 years of age with diagnosed asthma who lacked regular asthma care due to economic, transportation and language barriers.

Children with mild to severe persistent asthma who had uncontrolled asthma, ED visits, or hospitalizations due to asthma, or had frequent use of rescue inhalers, were recruited into the individual level asthma clinical assessment and management component of the project. Sixty-six children were referred to the program. Of these, 16 did not meet the recruitment/enrollment criteria for various reasons including moved away, not in age range or unable to contact. Of the children who were not enrolled, 6 were white, 1 was African American, 2 were American Indian, 1 was Hispanic; race was unknown for the other 6. Fifty children who met the criteria were enrolled. All 50 completed the study.

The average time of enrollment until completion of the last visit for each child, termed ''intervention'' was 11.2 months; it ranged from 1.2 to 23.9 months. The median intervention time was 9.6 months.

Patient centered asthma disease management and clinical care in accordance with the NAEPP guidelines was provided to participating children in nonclinical settings – their homes, childcare centers or schools. Asthma disease management was done under the direction of the PCP and the RADMP supervising physician. Through the various components of the program, the following activities were provided:

- Clinical asthma management
  - Clinical assessment and control monitoring.
  - Pulmonary function (FVC, FEV_1 and FEF 25–75%) measurements and exhaled nitric oxide (eNO) [an additional measure of lung inflammation].
  - Medication assessment and review and appropriate recommendations based on the NHLBI guidelines including inhaled corticosteroids and use of spacers.
  - Development and implementation of an Asthma Action Plan, based on the child's symptom history and/or personal best peak flow.
- Education
  - Culturally appropriate and literacy sensitive education and materials for children and families.
  - One on one asthma education sessions for each child.
  - Communication of pertinent information to physician, families, school nurses, teachers and others as deemed appropriate.
- Environmental assessment and remediation
  - Identification and securing of resources such as pillow and bed encasements to reduce irritants in the home.
  - Linking of services such as integrated pest management with community organizations.
  - Promoting an ''asthma friendly environment'' and reporting potential housing code violations that may worsen asthma symptoms.

Each intervention component was conducted by the respiratory therapist, who was also trained as a healthy home specialist. Each child was seen every 8–12 weeks, unless poor symptom control dictated more frequent intervention. Participating children were seen an average of eight times over the duration of the study. Usually these visits were conducted by the respiratory therapist in the home, school, or childcare center, though occasionally they were done in a clinic. Communication across the continuum of care was critical and constant. Each patient was treated individually, recognizing differences in learning style and coping strategies.

Pulmonary function tests were completed using a portable KOKO spirometer in the home, childcare center, and/or school setting. Daily calibrations were performed. The tests results were interpreted by a pediatric asthma specialist and forwarded to the patient's primary care provider. We report the baseline and final pulmonary function test results taken at each child's last visit in September 2011.

Environmental assessments and remediation were conducted in each of the children's homes. A list of the remediation options is included in Supplementary Table 3. The estimated total cost of home remediation for the 50 homes was $22,560; all services and materials were donated by local service organizations and businesses. Nine of the 50 participating children attended childcare centers that were environmentally remediated. An environmental follow-up was conducted by the Healthy Home Specialist on the scheduled asthma in-service date. Following education and home assessments, parents were given a commitment form to sign, stating that they would make every effort to reduce the levels of irritants such as mold and carbon monoxide in their homes and provide smoke-free environments around children.

Data were collected on healthcare utilization for three time periods: 12 months prior to enrollment and the beginning of the intervention, during the intervention and 12 months post-intervention. Hospital and ER visit data were captured electronically from encounters in the regional hospital; otherwise, the data were self-reported by the parent and/or legal guardian for healthcare encounters occurring elsewhere.

To evaluate potential significant differences between baseline and post-intervention measures, paired analyses were used. For lung function and eNO baseline-post comparisons, we used paired measurements taken at the initial intervention visit and the last intervention visit (September 2011) for 48 of the 50 children. Two of the children were unable to complete the test maneuver. The number of school absences 12 months pre-intervention and during the intervention was compared for each child for the 35 students with available school absence data. Lastly, we compared

differences for healthcare utilization for three time periods: 12 month pre-intervention, during the intervention, and 12 month post-intervention. Cost savings were estimated by first obtaining the average asthma ED visit and hospital admission cost from the hospital and NC Center for Health Statistics. The total number of healthcare visits (ED and hospital admissions) were multiplied by the per-visit cost at baseline and intervention completion, and 12 month and then subtracted to yield the difference. All statistical analyses, consisting of parametric and non-parametric methods, were conducted with SAS 8.2 (SAS Institute Inc., Cary, NC). All tests were two-tailed with no adjustments for multiple comparisons.

Results

Community-education in childcare centers and schools

Between 2009 and 2011, 11 asthma education in-services and 13 environmental remediations were conducted at 14 child-care centers in 12 counties and the Qualla Boundary. Approximately 3346 children attend these childcare facilities (Table 2). Among the sites, 259 administrative staff members participated in the asthma education sessions. Over 91% of participants committed to create smoke-free environments for the children and 93% pledged to create an asthma friendly environment. All 14 sites (100%) were determined to be smoke free.

Individual asthma assessment and management in children

A total of 50 children, 28 (56%) boys and 22 (44%) girls participated in the RADMP program between 2009 and 2011 (Table 3). The mean and median intervention period was 11.2 and 9.6 months, respectively, with a range from 1.2 to 23.9 months. The majority (76%) were enrolled in Medicaid. Among the children, 28% were American Indian, 24% were African American, 10% were Mexican American/Hispanic and 38% were Caucasian. The mean age of the participants was 8 years (range of 3–13). Fifty-eight percent of the participants were classified with moderate persistent asthma, 16% with severe persistent asthma and 26% with mild persistent asthma. At baseline, all 50 children used SABA rescue medication, and 64% used inhaled corticosteroids ''as needed''. At intervention completion, 48, or 96% of the children used inhaled corticosteroids as prescribed, 2 were on Singular only, and all children had asthma action plans. All 50 children had environmental assessments/remediations conducted in their homes.

Clinical lung function improved significantly from baseline to intervention completion. The average baseline FEV_1 was 85.6% of predicted, which increased to 98.7% at

Table 2. NACI community level intervention 2009–2011 asthma education in-services/environmental assessments.

Childcare centers (some on elementary school premises)	Site #	# Students enrolled	# Participants	% Of adults committing to a smoke free environment	% Of adults pledging to create an asthma friendly environment	Smoke FREE Site	Environment assessment complete
Buncombe County							
Mission Hospital Child Development Center	1	130	8	88%	88%	Yes	Yes
Cherokee County							
Marble Elementary/Child Development Center	2	120	9	100%	100%	Yes	Yes
Cherokee Indian Reservation							
Big Cove Child Care Center	3					Yes	Yes
Dora Reed Child Care Center	4					Yes	Yes
Cumulative Total: Above Child Care Centers		290	58	93%	100%		
Kituwah Academy/Child Care Center	5	56	22	82%	82%	Yes	Yes
Clay County							
Hayesville Elementary/Child Care Center	6	64	8	88%	88%	Yes	Yes
Graham County							
Robbinsville Elementary/Child Care Center	7					Yes	Yes
Robbinsville Middle & High School/Child Care Center	8					Yes	Yes
Cumulative Total: Above Child Care Centers		717	40	93%	95%		
Haywood County							
Hazelwood Elementary Child Care Center	9	505	33	94%	97%	Yes	Yes
Jackson County							
Smokey Mountain Elementary Child Care Center	10	400	18	94%	94%	Yes	Yes
Madison County							
Mars Hill Elementary Child Care Center	11	550	18	67%	83%	Yes	Yes
Mitchell, Avery, Watauga and Yancey Counties							
Mountain Heritage High Child Care Center (Yancey)	12					Yes	Yes
Intermountain Child Care Center (Avery, Watauga Counties)	13					Yes	Yes
Cumulative Total: Above Child Care Centers		412	39	95%	95%		
Swain County							
Bright Adventures Pre-K; Swain Co. School System	14	102	6	100%	100%	Yes	Yes
Totals		3346	259	91%	93%	100%	14

Table 3. Demographics of children participating in the RADMP project, $n = 50$.

Variable	Number	Percent
Gender		
Female	22	44
Male	28	56
Insurance		
Medicaid	38	76
Private	7	14
Tribal	2	4
None	2	4
Self pay	1	2
Age		
Age Mean and Range, years	8 (3–13)	
Ethnicity		
American Indian	14	28
Caucasian	19	38
African American	12	24
Hispanic/Mexican American	5	10
Severity		
Mild persistent	13	26
Moderate persistent	29	58
Severe persistent	8	16
Inhaled corticosteroid use PRN used at baseline – as needed	32	64
Rescue medicine (SABA)	50	100

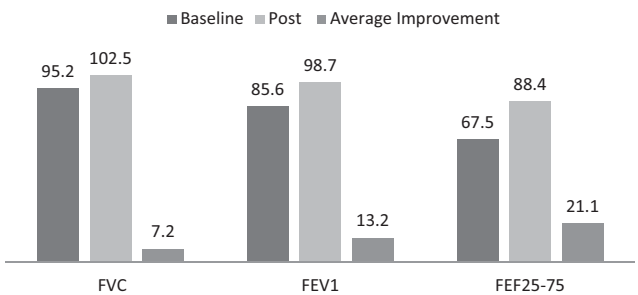

Figure 1. Average changes in pulmonary function (FVC, $p < 0.01$; FEV1, FEF 25–75, $p < 0.0001$, pairwise *t*-test), from baseline to intervention completion date (Post) (30 September 2011), $n = 48$.

follow up, a 13.2% difference (Figure 1). FEF (25–75%) showed the largest increase from baseline, at 21.1%, while FVC increased by 7.2%. These changes from baseline to intervention completion were all statistically significant ($p < 0.0001$). The reduction in exhaled NO from 23.89 to 20.6 was also statistically significant ($p < 0.05$). Figure 2 illustrates baseline to intervention completion change in FEV1 for each individual among 48 of the 50 children. For the large majority of the children FEV1 increased. Similar patterns were seen for FVC and FEF 25–75% (data not shown).

Similarly, school absences were markedly reduced from pre-intervention during the intervention ($p < 0.0001$), from a mean of 17 days to 8.8 days per school year (Figure 3).

Both asthma-related ED visits and hospitalizations decreased significantly ($p < 0.0001$) from baseline to 12 month post-intervention (Figure 4). The average number of ED visits decreased from 3.16 (SD 2.99, range 0–15) at baseline to 0.08 at 12 months post-intervention (SD 0.57, range of 0–4). The average number of hospitalizations decreased from a mean of 1.24 (SD 1.57, range of 0–6) at baseline to 0.02 (SD 0.14, range 0–1) at 12 months post-intervention. Figure 5 illustrates the dramatic reduction in total number of ED visits and hospitalization from the pre-intervention to during to post-intervention period.

These significant reductions in asthma-related healthcare utilization translated to major reductions in healthcare costs (Table 4). For these 50 children, estimated ED visit costs avoided were $146 300 in the 12 months post-intervention compared with pre-intervention. Hospital charges avoided were estimated $735 721 during the 12 months post-intervention for a total estimated $882 021 avoided in healthcare expenses 12 months post-intervention.

Discussion

This NACI funded demonstration project targeted underserved and impoverished children with asthma in rural western North Carolina. The community level component of this project successfully built support for creating an asthma friendly environment in 14 childcare facilities serving over 3000 children in a 20 county area and the Qualla Boundary. In the intensive individual asthma education and management component of the project, children who participated in the intervention had statistically significant decreases in asthma-related ED visits, hospital admissions and school absences. Lung function increased and exhaled nitric oxide decreased, indicating a reduction in airway inflammation. Asthma healthcare costs avoided were over three quarters of a million dollars for these 50 children alone.

The RADMP project serves a population at high risk for asthma and other chronic health problems and who face barriers including poverty, lack of transportation and access to treatment, which contribute to health disparities. Health education is extremely limited or nonexistent in most of these rural counties. Additional barriers include lack of asthma knowledge and healthcare professionals in these areas, under use or lack of controller (inhaled corticosteroid) medication and over-reliance of ED as source of care. Interventions that recognize the child and family as primary managers of the disease bring assistance to places where the family lives and works [10]. The RADMP project focuses on outreach and providing education and disease management to the community, families and their children.

The western North Carolina RADMP demonstration project was carefully designed to implement the key messages of the GIP report at both the community and individual levels of the intervention. These messages, which reinforce the Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma (EPR-3) recommendations, include the following: (1) assess asthma severity, (2) assess and monitor asthma control, (3) use inhaled corticosteroids, (4) use written asthma action plan, (5) control environmental exposures and (6) schedule follow-up visits.

In a recent Cochrane meta-analysis and literature review, educational asthma interventions were found to significantly reduce the risk of subsequent ED visits (RR 0.73, 95%CI 0.65–0.81, $N = 3008$), hospital admissions (RR 0.79, 95%CI 0.69–0.92, $N = 4019$), and unscheduled doctor visits (RR 0.68, 95%CI 0.57–0.81, $N = 1009$) [11]. Our study

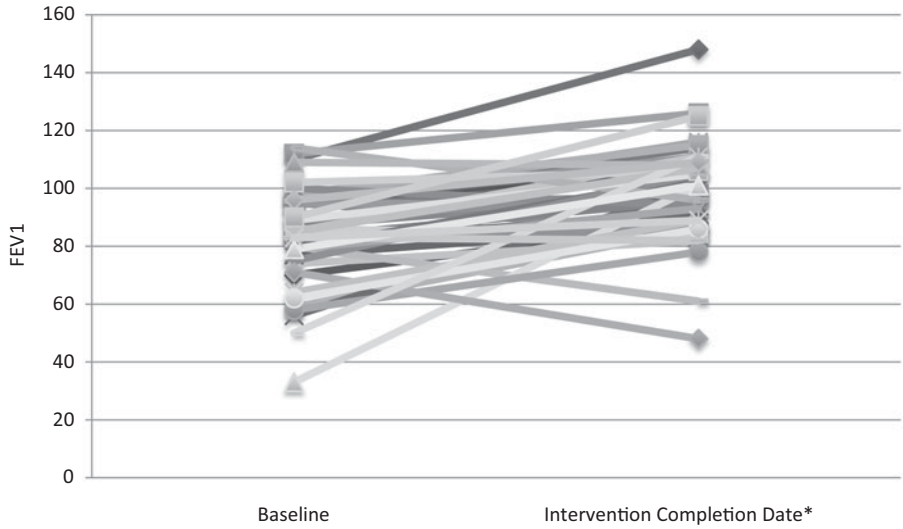

Figure 2. Individual changes in FEV1, baseline to intervention completion date (30 September 2011), $n = 48$.

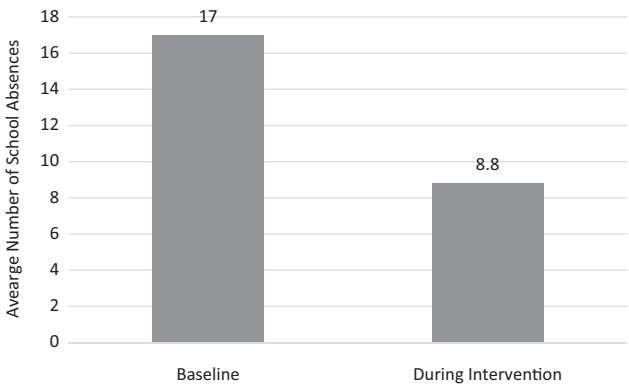

Figure 3. Average number of school absences: baseline, during intervention ($p < 0.0001$, pairwise t-test), $n = 35$.

also found substantial decreases in ED visits and hospitalizations both during and 12 months post-intervention. In this same Cochrane review with 38 studies involving 7843 children, findings were not conclusive with respect to clinical outcomes such as lung function [11]. In contrast, in our study we found significant increases at follow up for three measures of lung function, and a decrease for exhaled nitric oxide. While the addition of inhaled corticosteroid therapy is known to reduce lung inflammation, we do not believe that the improvements in clinical measures in this study were due only to regular ICS use. Busse et al. [12] showed in a recent randomized control trial in children with mild asthma that budesonide (a type of ICS) significantly improved asthma control. However, post-bronchodilator lung function decreased by 2.2% over the course of the study. ICS therapy has been shown to reduce acute asthma events and improves baseline lung function [13]. The multifaceted intervention with the 50 students yielded benefits – and it is difficult to discern which components of the intervention were most critical to this.

At the community level of the intervention, the asthma education in-services and environmental assessment/remediation addressed these GIP messages: (2) assess and monitor asthma control, (3) use inhaled corticosteroids, (4) use written asthma action plan and (5) control environmental exposures. Turcotte et al. [14] recently showed substantial reduction in healthcare utilization and costs after an in-home environmental assessment/remediation which included custom remediation plans [integrated pest management, cleaning (volunteers from community), and/or structural interventions]. Interestingly, the costs savings were approximately the same as our study ($820 304), although the Turcotte study was more than double in size. The environmental remediation costs in our study were covered by multiple local entities, including local churches, the Eblen Foundation, NC DENR and businesses such as Waste Pro, pest management companies and Lowes. Since the services and materials were donated, they were not included in our healthcare cost avoidance estimates. We should point out, however, that the outcome measure of the community wide intervention was adult willingness to pledge to improve – there is insufficient evidence from our study to specifically conclude the pledge led to actual environmental improvements or to a change in asthma control.

As noted by Brownson et al. [15], community-based demonstration projects translate research findings into practice, as large scale interventions designed to improve the population's health. The purpose of the NACI demonstration projects was to ''help inform the NACI about best practices to promote the adoption of asthma guidelines and improve quality of asthma care nationwide'' [5]. For a relatively low cost (less than two full time respiratory therapists), and with substantial forging and building of community member partnerships, the children's asthma improved dramatically and with notable healthcare cost savings.

A limitation of this demonstration project was the lack of a control group; each child served as his/her own control. However, for children with asthma ED visits, increased asthma management has already been shown to be effective in reducing ED visits [11] which precluded the use of a non-intervention group in this project. Given the manner in which the demonstration project was designed, there would have been ethical concerns in not providing education and

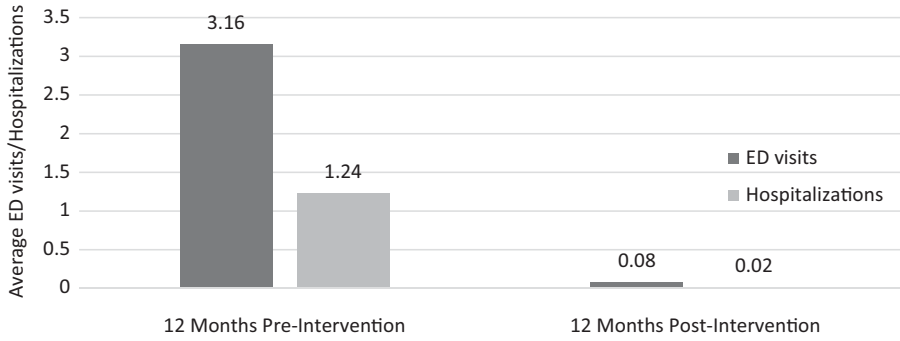

Figure 4. Average asthma-related ED visits, Hospital Admissions: 12-month pre-intervention, 12 months post-intervention (ED visits, hospital admissions, $p < 0.0001$, pairwise t-test), $n = 50$.

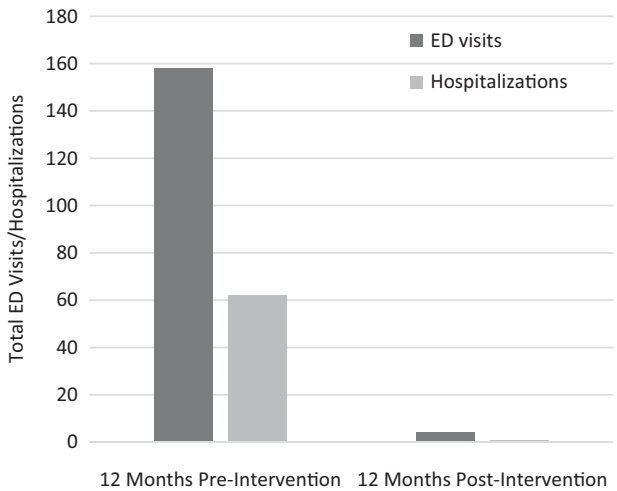

Figure 5. Total asthma-related ED visits, hospital admissions: 12-month pre-intervention, 12 months post-intervention (*ED visits, hospital admissions, $p < 0.0001$, pairwise t-test), $n = 50$.

Table 4. Asthma-related healthcare cost reduction, $n = 50$.

	(A) 12 Months prior to intervention	(B) 12 Months post-intervention	(C) 12-Month post-intervention cost avoidance (A–B)
ED visits[a]			
Total visits	158	4	
Total costs	$150 100	$3800	$146 300
Hospital admissions[b]			
Total hospitalizations	62	1	
Total charges	$747 782	$12 061	$735 721

[a]*Source*: Estimated cost of ED care from regional hospitals, based on National and State (NC) figures: $950/ED visit.
[b]*Source*: NC State Center for Health Statistics, 2009 Provisional Hospital Discharge Data: $12 061/hospitalization.

management to low income children with poorly managed asthma. In addition, the design of the demonstration project did not allow us to determine what specific aspects of the individual level intervention component were most effective in improving the children's healthcare utilization and quality of life.

However, the purpose of this project was to explore best practices for promoting the adoption of asthma guidelines in this western 20 county region of North Carolina. With its focus on patient centered care, programs such as RADMP should be incorporated to the Affordable Care Act related changes that are occurring in the US healthcare system. Next steps for NAEPP and NACI should include funding projects that ''adapt effective approaches to new communities and means to institutionalize them so that their benefits are widely available'' [10].

To our knowledge this is the first NACI demonstration project evaluation to appear in peer reviewed literature. The outcomes were standard measures of healthcare utilization including emergency department visits and hospital admissions. Clinical outcomes of lung function and exhaled nitric oxide were rigorously measured. The use of 12 months pre-intervention baseline, during, and 12 months post-intervention measurements allowed us to capture changes in children's health.

Strengthening connections between childcare and school, home and the clinic resulted in significant improvements for low income underinsured children in rural western North Carolina. The RADMP model of asthma treatment and management emphasizes collaboration, trust, and engagement among patients, caregivers and community healthcare providers to provide an individualized patient care regimen. Programs like RADMP can help address the problem of sub-optimal asthma management in rural underserved and impoverished children.

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Declaration of interest

There were no conflicts of interests for the authors. The National Asthma Control Initiative (NACI) was funded by the National Asthma Education and Prevention Program of the NHLBI. This project was supported, in part, by NIH contract number HHSN268200800317U. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NHLBI, NIH or DHHS.

References

1. Moorman JE, Akinbami LJ, Bailey CM, Zahran HS, King ME, Johnson CA, Liu X. National Surveillance of Asthma: United States, 2001–2010. Hyattsville (MD): National Center for Health Statistics; 2012.
2. Nokela M, Arnlind MH, Ehrs PO, Krakau I, Forslund L, Jonsson EW. The influence of structured information and monitoring on the outcome of asthma treatment in primary care: a cluster randomized study. Respiration 2010;79:388–394.
3. National Asthma Education and Prevention Program N. Guidelines Implementation Panel Report for: Expert Panel Report 3 – Guidelines for the Diagnosis and Management of Asthma, Partners Putting Guidelines into Action. Washington, DC: NHLBI; 2008.
4. Qamar N, Pappalardo AA, Arora VM, Press VG. Patient-centered care and its effect on outcomes in the treatment of asthma. Patient Relat Outcome Meas 2011;2:81–109.
5. National Asthma Control Initiative. Available from: http://www.nhlbi.nih.gov/health/prof/lung/asthma/naci/ [last accessed 19 May 2014].
6. Foundation AEC; 2014. Available from: http://datacenter.kidscount.org/ [last accessed 25 May 2014].
7. Statistics NSCfH. 2012 North Carolina Hospital Discharges with a Primary Diagnosis of Asthma; 2012. Available from: http://www.schs.state.nc.us/SCHS/data/databook/CD18%20Asthma%20hospitalizations%20by%20county.html [last accessed 29 May 2014].
8. Lich KH, Travers D, Psek W, Weinberger M, Yeatts K, Liao W, Lippmann SJ, et al. Emergency department visits attributable to asthma in North Carolina, 2008. N C Med J 2013;74:9–17.
9. Shuler M, Russell DW. Mission Children's Hospital's Regional Asthma Disease Management Program. N C Med J 2013;74:394–395.
10. Clark NM. Community-based approaches to controlling childhood asthma. Annu Rev Public Health 2012;33:193–208.
11. Boyd M, Lasserson TJ, McKean MC, Gibson PG, Ducharme FM, Haby M. Interventions for educating children who are at risk of asthma-related emergency department attendance. Cochrane Database Syst Rev 2009;(2):CD001290.
12. Busse WW, Pedersen S, Pauwels RA, Tan WC, Chen YZ, Lamm CJ, O'Byrne PM. The Inhaled Steroid Treatment As Regular Therapy in Early Asthma (START) study 5-year follow-up: effectiveness of early intervention with budesonide in mild persistent asthma. J Allergy Clin Immunol 2008;121:1167–1174.
13. Castro-Rodriguez JA, Rodrigo GJ. The role of inhaled corticosteroids and montelukast in children with mild-moderate asthma: results of a systematic review with meta-analysis. Arch Dis Child 2010;95:365–370.
14. Turcotte DA, Alker H, Chaves E, Gore R, Woskie S. Healthy homes: in-home environmental asthma intervention in a diverse urban community. Am J Public Health 2014;104:665–671.
15. Brownson RC, Riley P, Bruce TA. Demonstration projects in community-based prevention. J Public Health Manag Pract 1998;4:66–77.

Supplementary material available online

Supplementary Tables 1–3.