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KEY WORDS

asthma, cost analysis, community health worker, emergency department visits, health disparities, health outcomes, hospitalizations, nurse case management, pediatrics, return on investment

ABBREVIATIONS

AAP—Asthma Action Plan
CAI—Community Asthma Initiative
CHW—Community Health Worker
CI—confidence interval
ED—emergency department
FTE—full-time equivalent
FY—fiscal year
GEE—generalized estimating equation
IPM—Integrated Pest Management
NAEPP—National Asthma Education Prevention Program
QI—quality improvement
ROI—return on investment

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WHAT'S KNOWN ON THIS SUBJECT: Comprehensive home visits conducted by Community Health Workers including environmental remediation and office-based nurse case management improve asthma outcomes.

WHAT THIS STUDY ADDS: Implementation of a comprehensive quality improvement program as part of enhanced care of pediatric asthma patients with a history of hospitalizations or emergency department visits can improve health outcomes and be cost-effective as well as reduce health disparities.

abstract

OBJECTIVE: The objective of this study was to assess the cost-effectiveness of a quality improvement (QI) program in reducing asthma emergency department (ED) visits, hospitalizations, limitation of physical activity, patient missed school, and parent missed work.

METHODS: Urban, low-income patients with asthma from 4 zip codes were identified through logs of ED visits or hospitalizations, and offered enhanced care including nurse case management and home visits. QI evaluation focused on parent-completed interviews at enrollment, and at 6- and 12-month contacts. Hospital administrative data were used to assess ED visits and hospitalizations at enrollment, and 1 and 2 years after enrollment. Hospital costs of the program were compared with the hospital costs of a neighboring community with similar demographics.

RESULTS: The program provided services to 283 children. Participants were 55.1% male; 39.6% African American, 52.3% Latino; 72.7% had Medicaid; 70.8% had a household income $<$$25 000. Twelve-month data show a significant decrease in any ($\geq$1) asthma ED visits (68.0%) and hospitalizations (84.8%), and any days of limitation of physical activity (42.6%), patient missed school (41.0%), and parent missed work (49.7%) (all $P < .0001$). Patients with greatest functional impairment from ED visits, limitation of activity, and missed school were more likely to have any nurse home visit and greater number of home visits. There was a significant reduction in hospital costs compared with the comparison community ($P < .0001$), and a return on investment of 1.46.

CONCLUSIONS: The program showed improved health outcomes and cost-effectiveness and generated information to guide advocacy efforts to finance comprehensive asthma care. *Pediatrics* 2012;129:465–472

Developing and testing the effectiveness of new chronic care models is essential for cost savings under health care reform. Asthma is 1 of the most common chronic illnesses for children in the United States, and rates have reached historically high levels nationally with large racial/ethnic health disparities.[1,2] For children <18 years, asthma rates had increased to 9.6% in 2009.[3] At the time of planning for this project (2003–2005), the asthma prevalence rate was 9.5% overall in Massachusetts, but the average prevalence reported in the urban Boston Public Schools was 16% with 5 schools reporting rates >24%. In addition, asthma was the leading cause of hospitalization at Children's Hospital Boston (hereafter referred to as "Children's") with 70% of children hospitalized with asthma from urban, low-income neighborhoods in Boston. There were substantial health disparities with rates of asthma-related hospitalizations 5 times higher for black (14.2 per 1000) and Latino (14.1 per 1000) compared with white children (2.9 per 1000).[4] Care for children with poorly controlled asthma provides an important opportunity for the development of novel models of care and new payment systems under health care reform.

The National Asthma Education Prevention Program (NAEPP)[5] provides guidelines for asthma management that have been effective in improving health outcomes including decreasing hospitalization and emergency department (ED) visits.[5,6] Previous studies, including several randomized clinical trials, have demonstrated that multifaceted community-based environmental interventions for children with asthma that follow the NAEPP guidelines are particularly successful.[7–16] Effective interventions incorporating trained community health workers (CHWs) who provide asthma education and environmental materials (such as bedding encasements, cleaning materials, and HEPA vacuums) reduce household antigens, improve quality of life and symptom-free days, and decrease hospitalizations beyond office-based nurse case management.[8–11]

This program was modeled after several community-based comprehensive programs that address health disparities. The "Yes We Can Urban Asthma Partnership" and other culturally sensitive community-based programs provide a road map for comprehensive approaches that improve asthma-symptom-free days and reduce ED visits.[12–14] The Harlem Children's Zone Asthma Initiative focused on a specific geographic community so that health outcomes could be tracked, and demonstrated reduced ED and urgent-care office visits through a combination of care coordination and CHW home visits.[15,16] The combination of CHW asthma education and office-based nurse case management have demonstrated cost-effectiveness[17] and improved quality of life.[18] However, none of these programs have incorporated nurse home visits to address medication issues and compliance as well as environmental support. In addition, limited cost analyses of comprehensive programs are available.[19]

As we implemented the current program, we used the health outcomes presented by Lieu and colleagues, who demonstrated that asthma quality improvement (QI) indicators can be tracked including ED visits and hospitalizations.[20] QI efforts to develop individualized care plans with an up-to-date Asthma Action Plan (AAP) have been shown to reduce acute care visits.[21] The Community Asthma Initiative (CAI) was developed to address health disparities in the Boston neighborhoods most impacted by asthma by providing an enhanced model of care for children previously seen in the ED or hospitalized because of asthma. The objective of this article is to evaluate the CAI health and quality-of-life outcomes, to compare cost data with a similar community, and to calculate the return on investment (ROI) to society for this QI initiative.

METHODS

Setting

CAI was designed to reduce health disparities by addressing asthma issues at multiple levels of the socioecological model.[22,23] A community-based participatory approach involving active Community and Family Advisory Boards[24] and evidence from previous programs were used in the design. The model was developed for children 2 to 18 years old living in 4 urban zip codes showing a high prevalence of asthma and encompassing diverse underserved communities neighboring a major pediatric urban hospital and the hospital's community health center. The model includes (1) nurse case management and coordination of care with primary care and referral services, (2) nurse (bilingual) or nurse-supervised CHW (bilingual/bicultural in Spanish) home visits for asthma education, environmental assessment, and remediation materials (HEPA vacuum, bedding encasements, and Integrated Pest Management (IPM) materials tailored to the needs of the family), and connection to community resources; (3) referral to an IPM exterminator or Inspectional Services (http://www.cityofboston.gov/isd/housing/bmc/) when indicated.

Population

CAI services were offered to children from the 4 zip codes who had a recent ED visit or hospitalization. The nurse case manager (hereafter referred to as "nurse") reviewed daily, weekly, and monthly admission and ED logs for patients with the diagnosis codes for asthma. Patients were prioritized at greatest need for services because of a hospitalization or multiple ED visits in

the past year. Patients with intake from October 1, 2005 to June 30, 2008 had sufficient follow-up time to be included in this study. Services and follow-up care were provided for 1 year.

Patients were contacted by the nurse through face-to-face visits during hospitalizations or through telephone contact, and were offered case management services and home visits. Clinical releases were obtained to allow communication with providers and home visitors contracted through a community agency. Baseline, 6-, and 12-month standardized interviews were completed as part of clinical care to assess asthma symptoms and control, number of ED visits and hospitalizations, days of limitation of physical activity, child missed school days, parent/guardian missed work days, insurance access, up-to-date AAP (updated within the past year), environmental issues, and medication adherence. Asthma severity scores were obtained from AAPs, modified through clinical assessment by the nurses and discussions with primary care providers, and categorized as intermittent, or mild, moderate, or severe persistent asthma according to the NAEPP guidelines.[5]

For the cost analyses, CAI patients were compared with children from 4 similar zip code neighborhoods (not statistically different): similar diverse low-income communities (41.2% vs 59.2% black; 46.1% vs 34.6% Hispanic), male gender (53.9% vs 59.8%), mean age (7.9 $\pm$ 4.4 years vs 7.1 $\pm$ 5.4 years), and socioeconomic status (77.5% vs 73.3% Medicaid) with ED visits or hospitalization during the same study period. From hospital administrative data for the CAI and comparison community, the number of hospitalizations and ED visits, and costs were assessed the year before the baseline visit, and 1 and 2 years of follow-up. Children's Internal Review Board waived the need for consent for the enhanced clinical care program, and approved access to case management data and hospital administrative databases for intervention and comparison groups with waiver of informed consent for the evaluation.

Statistical Analyses

Data were analyzed with the use of Stata version 10.1. Outcomes obtained by parental report included whether patients in 6-month time intervals had ED visits or hospitalizations (events), or limitation of physical activity, missed school or parent/guardian missed work (days) because of asthma, and if the patient had an up-to-date AAP. The events/days were analyzed both as dichotomous variables of the percentage of patients with $\geq$1 events/days versus none, and continuous variables of the number of events/days. Demographic characteristics such as age, gender, race/ethnicity (black/African American versus others, Hispanic versus others), insurance status (private versus public), household income ($<$\$25 000 versus higher income), and asthma severity scores were collected. For the trichotomous variable for asthma severity (severe, moderate, others), indicator variables were developed for moderate versus others and severe versus others for the multivariate analyses. The number of home visits and any ($\geq$1) nurse home visits were tracked. Analyses evaluated changes from baseline to 6 or 12 months, or the combined follow-up variable (with the use of the latest follow-up visit available).

For the intervention group, attrition analysis for demographic and asthma characteristics was performed with the use of χ^2 tests for categorical variables and unpaired t tests for continuous variables comparing baseline values for initial and follow-up time points. Paired analyses used the McNemar test to assess differences in dichotomous outcomes between the baseline and follow-up measurements. Paired t tests were applied for comparisons of continuous variables at 2 time points. Dichotomous outcomes across 3 time points were compared by using unadjusted and adjusted repeated-measures random intercept logistic regression models (displayed with odds ratios with their 95% confidence interval [CI]). Generalized estimating equation (GEE) repeated measures random intercept Poisson regression analyses tested differences for the counts of number of events/days for outcome variables (displayed with the change in number of events/days and 95% CI). Because of a small increase in all outcomes at 12 months, a quadratic term was inserted in the equation for multivariate models to correct for seasonal variation.

Hospital administrative data were used to compare the admissions, ED visits, and hospital cost for the intervention and comparison populations for Fiscal Year (FY) 2006. Cost of the ED visits and hospitalizations for each patient was calculated with the baseline event included in the previous year and assessing events at 1 and 2 years of follow-up.[19] A comparison group was identified for those with an ED visit or hospitalization from demographically similar neighborhoods; the first visit in the time period was used as the baseline visit. Hospital charges were adjusted with the appropriate Medicare modified rate ($\sim$0.42) to estimate hospital costs and brought to net present value (current dollar amounts). The ROI was calculated for the CAI patients, comparing the cost savings for society (due to the reduction in ED visits and hospitalizations) over the cost of the clinical program (ROI = difference in hospital costs of baseline from year 1 and year 2 for CAI patients divided by the cost of the program). The clinical cost of the program in FY2006 for 102 new families included 1.0 full-time equivalent (FTE) nurse, 1.0 FTE subcontracted CHW, 0.25 FTE program

coordinator, 0.1 program director, 0.1 FTE evaluator, IPM materials, and IPM exterminator services (including $194 246 personnel, $58 712 materials, and $5000 exterminator services).

RESULTS

During the study period, 562 children were identified and 283 (50.4%) children's families agreed to participate. The participating children were 55.1% male; 39.6% black, 52.3% Latino; 72.7% Medicaid; 70.8% household income <$25 000 (Table 1). One hundred twenty (42.9%) were scored as having moderate or severe persistent asthma; the remainder of the children had intermittent (24.3%) or mild persistent asthma (32.9%) with exacerbations resulting in ED visits or hospitalizations. One hundred fourteen (40.3%) were enrolled face-to-face by the nurse during the hospitalization and the rest by phone. A total of 203 (71.7%) families had a mean of 1.28 home visits (±1.27 SD), including 176 nurse visits (performed by nurse, or CHW and nurse) and 145 CHW visits, and 40 IPM exterminator visits. The retention rate was 68% at 6 months and 60% at 1 year, and 78% of participants had follow-up at 1 or both time points (follow-up). Attrition analyses showed minimal differences for baseline values of variables for the population compared with those cared for at 6 or 12 months of follow-up, with the exception of fewer low-income patients at 6 months, and fewer Hispanic patients at 12 months. Demographic variables were controlled for in the final models.

There were highly significant (all $P <$ .0001) reductions in any (≥1) ED visits (66.5% at 6 months, 68.0% at 12 months, and 56.0% with any follow-up), hospitalizations (79.7%, 84.8%, 82.6%), days of limitation of physical activity (50.4%, 42.6%, 38.7%), patient missed school days (44.9%, 41.0%, 42.3%), and parent missed work days (53.2%, 49.7%, 47.7%) (Fig 1). There was a large improvement in having an up-to-date AAP at follow-up (59.1%, 55.3%, 55.6%; $P <$ .0001). Also, for the continuous variables, there were similarly highly significant reductions in the number of events/days at 6 and 12 months (all $P <$ .0001) (Table 2).

TABLE 1 Baseline Demographic Information and Asthma Characteristics for Community Asthma Initiative Participants

	Baseline $N = 283$ n (%)
Age, mean in years (SD) ($n = 283$)	7.9 (4.6)
Gender (male) ($n = 283$)	156 (55.1)
Insurance (private) ($n = 282$)	66 (23.4)
Household Income (<$25 000) ($n = 257$)	82 (70.8)
Race/ethnicity ($n = 283$)	
Hispanic	148 (52.3)
Black/African American	112 (39.6)
Other	23 (8.1)
Asthma Severity Score ($n = 280$)	
Intermittent	68 (24.3)
Mild persistent	92 (32.9)
Moderate persistent	99 (35.4)
Severe persistent	21 (7.5)
Enrollment ($n = 283$)	114 (40.3)
Face-to-face during hospitalization	114 (40.3)
Number of families receiving home visits	203 (71.7)
Mean number of home visits/family (SD)	1.28 (1.27)
Total number of nurse or CHW home visits	321
Number nurse or CHW and nurse visits (nurse visits)	176 (54.8)
Number of CHW-performed visits	145 (45.2)
Number of families receiving IPM extermination services	30 (14.7)
Number of IPM extermination service visits	40

Multivariate logistic regression models for dichotomous outcomes (controlling for demographic variables, asthma severity, number of home visits, any nurse home visits, and a quadratic term) showed that there were greatly reduced odds of having any ED visits, hospitalizations, days of limitation of activity, patient missed school days, parent/guardian missed work days, and increased odds of an up-to-date AAP at follow-up (Table 3). Patients with greatest functional impairment from ED visits and missed school were more likely to have any nurse home visits and greater number of home visits, respectively.

GEE for continuous variables, controlling for the same variables, showed significantly decreased number of ED visits (−2.84 events; 95% CI −3.98 to −1.71), hospitalizations (−3.16; −5.06 to −1.26), days of limitation of activity (−2.11 days; 95% CI −2.68 to −1.53), missed school days (−0.75; −1.11 to −0.40), and missed parent/guardian work days (−1.31; −1.87 to −0.74). Those with more home visits and any nurse visits were associated with more days of limitation of physical activity (0.06; 0.02–0.11) and (0.14; 0.01–0.27), and missed school (0.04; 0.00–0.07) or (0.23; 0.13–0.32), respectively.

The cost of ED visits and hospitalizations for FY2006 CAI patients and a comparison population 1 year back and 2 years forward by using hospital administrative data showed remarkable differences (Fig 2). CAI patients started out with higher average cost per patient in the 1 year before entering the program compared with the comparison community, had similar costs at 1 year (with a greater decline from baseline for CAI patients), and had further reduction in costs at 2 years (repeated-measures analysis comparing intervention and comparison groups was $P <$ .001). Services were provided for 1 year with ~10% of patients needing care after the first year. The cost of the clinical program was $2529/child and the savings for the intervention group was $3827/child over 2 years of follow-up yielding a ROI of 1.46. In other words, for every dollar spent on the program, 1.46 dollars were saved to society because of reduced ED visits and hospitalizations.

DISCUSSION

CAI augmented traditional asthma care by providing nurse case management, nurse and/or CHW home visits, asthma

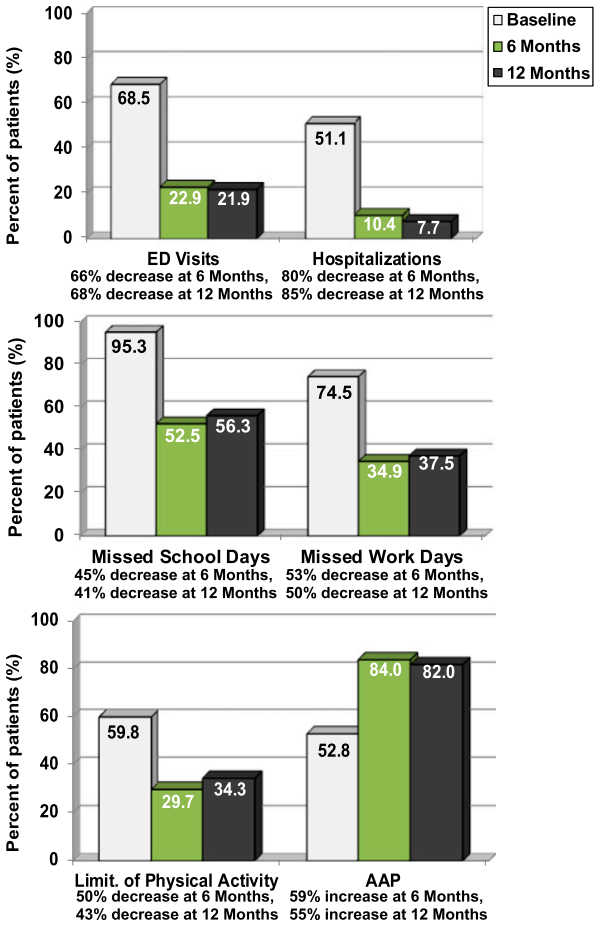

FIGURE 1

Community Asthma Initiative dichotomous outcomes at baseline, 6 months, and 12 months. Percentage of patients who experienced any (≥1 versus none) ED visits, hospitalizations, missed school days, missed work days (parents/caregivers), limitation of physical activity, and AAP for 283 children (all $P \leq .0001$).

education, and environmental assessment and remediation based on the evidence of previous national programs. The evaluation of this QI initiative has demonstrated a significant reduction in asthma ED visits, hospitalizations, limitation of physical activity, missed school, and parent/guardian missed work at 6 and 12 months of follow-up. The improvements in hospital costs were particularly remarkable when compared with the demographically similar diverse, low-income neighborhoods that had not received services during the study period. The continued reduction in cost at 2 years may indicate the ongoing improvement due to reduction in allergens through IPM and continued use of controller medications.

TABLE 2 The Community Asthma Initiative Continuous Outcomes

	Continuous Outcomes (3 Time Points)			
	Baseline	6 mo	12 mo	*P* (Repeated Measures)
ED visits	1.0	0.3	0.3	<.0001
Hospitalizations	0.5	0.1	0.1	<.0001
Days of limitation of physical activity	2.7	1.2	1.2	<.0001
Missed school days	5.1	3.1	2.4	<.0001
Missed work days	2.1	1.1	1.1	<.0001

Number of events or days at baseline, 6 months, and 12 months using GEE (unadjusted) repeated-measures analyses for continuous outcomes, including number of ED visits, hospitalizations, days of limitation of physical activity, child missed school days and parental missed work days ($N = 283$).

Home visits by CHWs and nurses allow the care system to reach families in their own homes to provide asthma education and can address the obstacles to good asthma control.[5] The CAI patients identified from these low-income communities were primarily black and Hispanic, and the program was developed to reduce health disparities for these populations. A comprehensive treatment plan needs to address social determinants of health, such as exposure to high levels of asthma triggers in the form of pests, mold, and dust found in poor housing and deteriorating schools, and chronic stress due to community violence.[25] The home environmental issues that families face required more aggressive services to reduce common asthma triggers than we originally anticipated. CAI provided all patients with HEPA vacuums and bedding encasements, environmental materials tailored to their needs, and IPM extermination on a case-by-case basis. Culturally sensitive communication about asthma treatment and medications also helped to address the personal beliefs of patients and their families and to identify barriers to adherence. Not surprisingly, nurse home visits were provided to patients with more ED visits and addressed the medication issues in greater detail. Nurse home visits and CHW visits closely supervised by nurses have not been reported in previous published initiatives, and their added value should be investigated further.

The changes in the comparison community over time may have reflected some degree of "regression to the mean," because some patients may not require subsequent ED visits or hospitalizations after 1 episode. Also, the comparison neighborhoods controlled for the impact of community-wide

TABLE 3 Logistic Regression Models for Dichotomous Outcomes (≥1 Versus None) Adjusted for Quadratic Term, Age, Gender, Race/Ethnicity, Number of Home Visits, Any Nurse Visits, Income, Insurance, and Asthma Severity

	Days of Limitation of Physical Activity OR (CI)	ED Visits OR (CI)	Admissions OR (CI)	Missed School Days OR (CI)	Missed Work Days OR (CI)	Up-to-date AAP OR (CI)
χ^2 for model	46.2[a]	117.3[a]	92.5[a]	87.05[a]	84.9[a]	76.1[a]
P value	<.0001[a]	<.0001[a]	<.0001[a]	<.0001[a]	<.0001[a]	<.0001[a]
Follow-up	0.09 (0.02–0.40)[a]	0.01 (0.00–0.04)[a]	0.01 (0.00–0.08)[a]	0.00 (0.00–0.01)[a]	0.01 (0.00–0.03)[a]	63.81 (11.85–343.60)[a]
Quadratic term	1.66 (1.16–2.39)[a]	2.68 (1.75–4.11)[a]	2.38 (1.34–4.21)[a]	3.72 (2.43–5.70)[a]	2.98 (1.98–4.49)[a]	0.42 (0.27–0.64)[a]
Age	0.99 (0.94–1.03)	0.95 (0.91–0.99)[a]	0.96 (0.91–1.01)	0.96 (0.91–1.02)	0.89 (0.83–0.95)[a]	1.01 (0.95–1.06)
Male	0.88 (0.59–1.30)	0.82 (0.56–1.19)	1.06 (0.68–1.66)	0.61 (0.39–0.96)[a]	0.79 (0.46–1.34)	1.24 (0.78–1.96)
Hispanic	1.48 (0.53–3.70)	1.45 (0.65–3.24)	2.87 (1.03–7.98)[a]	1.30 (0.51–3.28)	2.81 (0.96–8.29)	0.51 (0.19–1.37)
African American	2.09 (0.84–5.17)	1.06 (0.48–2.36)	3.4 (1.24–9.37)[a]	1.47 (0.58–3.68)	2.48 (0.86–7.16)	0.63 (0.23–1.68)
Number of home visits	1.07 (0.91–1.26)	1.00 (0.86–1.17)	1.06 (0.88–1.28)	1.36 (1.11–1.67)[a]	1.12 (0.86–1.46)	1.33 (1.06–1.68)[a]
Any nurse visit	1.39 (0.93–2.10)	1.59 (1.07–2.35)[a]	1.28 (0.80–2.04)	1.48 (0.93–2.37)	1.30 (0.74–2.28)	1.28 (0.78–2.10)
Low income	1.00 (0.58–1.71)	1.10 (0.64–1.89)	0.70 (0.38–1.29)	0.74 (0.39–1.41)	0.81 (0.43–1.55)	0.70 (0.37–1.32)
Private insurance	0.87 (0.46–1.65)	1.19 (0.65–2.18)	1.41 (0.70–2.82)	0.85 (0.42–1.71)	1.44 (0.68–3.07)	1.12 (0.54–2.30)
Moderate persistent asthma[b]	2.01 (1.32–3.07)[a]	1.17 (0.78–1.75)	0.74 (0.45–1.22)	1.19 (0.74–1.91)	1.00 (0.56–1.79)	3.39(2.01–5.73)[a]
Severe persistent asthma[c]	3.71 (1.73–7.98)[a]	2.56 (1.24–5.28)[a]	2.16 (0.96–4.89)	2.17 (0.83–5.66)	2.59 (0.86–7.79)	4.52 (1.52–13.45)[a]

Quadratic term was added because of the small increase in outcomes at 1 year compared with 6 months (reflecting a similar time of year as enrollment). Continuous variables included age and number of home visits.

[a] Significant results.

[b] Moderate persistent asthma = moderate persistent versus all others (indicator variable).

[c] Severe persistent asthma = severe persistent versus all others (indicator variable).

changes in asthma care, case management, and education. CAI patients were selected to be at greatest need of services by the nurse case manager and therefore showed higher initial cost, but ended up with costs similar to the comparison community at the end of the first year, and even lower costs at the end of the second year, which resulted in significant cost savings. Identification of an ideal comparison group is challenging, and our program was able to compare costs with demographically similar zip code neighborhoods. The use of the nonenrolled population in the same neighborhoods as a comparison group would reflect additional biases, because nonrespondents may have higher risks of poorer outcomes owing to the inability to be contacted and the refusal of enhanced care. Future matching strategies or risk adjustment for patients with initial hospitalizations might help correct the differential baseline cost of the 2 populations.

There were strengths and limitations to this study, because CAI was not a randomized clinical trial. The comparison data were drawn from hospital administrative data, but similar case management information was not available for the comparison group. The retention rate was lower than ideal, but reasonable for a voluntary QI study with no evidence of differential attrition. Additional initiatives may need to be developed to reach the "unreachable" populations not served by the program. The regression analyses indicated that patients with greater functional impairment had nurse visits and more home visits. However, the analyses could not separate out the impact of specific services. Because administrative data were used for the cost evaluation of CAI and for the comparison population, there were no biases due to lack of follow-up for the cost analyses.

Hospital administrative data cannot identify care at other hospitals; however, parental reports contain information across institutions as well as quality-of-life information, but they may lack accuracy. Parent and hospital administrative data were remarkably similar in this study and complemented each other. The cost estimate is conservative, because some of the staff time included in the analyses was used for CHW training and supervision, community meetings and collaborations, program planning, and evaluation in

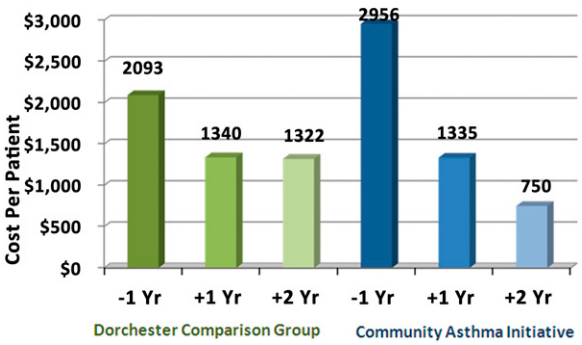

FIGURE 2
Cost of ED visits and hospitalizations for Community Asthma Initiative patients ($N = 102$) and comparison population (Dorchester Comparison Group) ($N = 559$) 1 year back (−1 Yr) and 2 years forward (+1 Yr and +2 Yr) (FY2006) (repeated-measures analysis comparing intervention and comparison groups, $P < .001$).

addition to patient care. The cost analysis did not include physician fees or financial estimates of impact on quality of life, and so the ROI underestimates the true cost savings. Future cost analyses should consider merging program information with insurance company data to include the costs of urgent care visits and medications that may increase when asthma is in better control and patients have more connection to their primary care providers.[2]

These remarkable results provide a model of effective care for high-risk asthma patients with substantial cost savings. The initial ROI calculation of 1.46 exceeds the break-even threshold of 1.0. Case management and home visits combined have helped patients who previously needed a higher level of care to have better control of their asthma. CAI incorporates a culturally sensitive, family-centered approach through home visits and care coordination, and is based in the community, as recommended by the Institute of Medicine's chronic care model.[26,27] Cost-effectiveness calculations support the business case for payers to cover these chronic care services and materials that are not reimbursed in a fee-for-service system.[28] The program has partnered with asthma policy organizations in Massachusetts to develop the "Investing in Best Practices for Asthma: A Business Case"[29] that moved ahead policy changes for care of children with asthma.

CAI provides an effective enhanced-care model that could be included in a bundled or global payment system to reduce the cost of asthma care to society and improve the health and the quality of the life of children living with asthma. The CAI model can be used to respond to the health care reform call for "accountable care organizations" and expansion of care under the medical homes for patients with chronic illnesses.[30] Accountable care organizations are responsible for the quality of care, as measured by standard outcome metrics,[31] and would receive bundled or global payments for care with potential shared savings for providers and payers.[32,33] CAI has started working with Medicaid and other stakeholders to develop and implement a bundled payment pilot.

CONCLUSIONS

CAI was developed to address health disparities for urban low-income children, and the cost-effectiveness of the program has generated information to guide advocacy efforts to finance comprehensive asthma care for children.

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