Research Article

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A Cost-Benefit Analysis of a State-Funded Healthy Homes Program for Residents With Asthma: Findings From the New York State Healthy Neighborhoods Program

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ABSTRACT

Context: Despite considerable evidence that the economic and other benefits of asthma home visits far exceed their cost, few health care payers reimburse or provide coverage for these services.

Objective: To evaluate the cost and savings of the asthma intervention of a state-funded healthy homes program.

Design: Pre- versus postintervention comparisons of asthma outcomes for visits conducted during 2008-2012.

Setting: The New York State Healthy Neighborhoods Program operates in select communities with a higher burden of housing-related illness and associated risk factors.

Participants: One thousand households with 550 children and 731 adults with active asthma; 791 households with 448 children and 551 adults with asthma events in the previous year.

Intervention: The program provides home environmental assessments and low-cost interventions to address asthma trigger–promoting conditions and asthma self-management. Conditions are reassessed 3 to 6 months after the initial visit.

Main Outcome Measures: Program costs and estimated benefits from changes in asthma medication use, visits to the doctor for asthma, emergency department visits, and hospitalizations over a 12-month follow-up period.

Results: For the asthma event group, the per person savings for all medical encounters and medications filled was $1083 per in-home asthma visit, and the average cost of the visit was $302, for a benefit to program cost ratio of 3.58 and net benefit of $781 per asthma visit. For the active asthma group, per person savings was $613 per asthma visit, with a benefit to program cost ratio of 2.03 and net benefit of $311.

Conclusion: Low-intensity, home-based, environmental interventions for people with asthma decrease the cost of health care utilization. Greater reductions are realized when services are targeted toward people with more poorly controlled asthma. While low-intensity approaches may produce more modest benefits, they may also be more feasible to implement on a large scale. Health care payers, and public payers in particular, should consider expanding coverage, at least for patients with poorly controlled asthma or who may be at risk for poor asthma control, to include services that address triggers in the home environment.

KEY WORDS: asthma, asthma intervention, cost-benefit analysis, economics, healthy homes, healthy housing, housing

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According to a 2014 survey, the vast majority of public and private health care payers do not provide or pay for home-based asthma services, with only 13 states reporting some Medicaid coverage and only 7 reporting that any private payers provide or reimburse home-based asthma services.[1] However, numerous studies and systematic reviews have shown that home-based environmental interventions significantly reduce asthma morbidity and provide significant savings to our health care system and society.[2-22] An economic analysis by the Community Preventive Services Task Force concluded that home-based, multitrigger, multicomponent interventions are a good investment, with each $1 invested yielding $5.30 to $14.00 in benefits (cost-benefit ratios of 5.3 and 14.0, respectively).[23] Three recent studies yielded more modest ratios (ranging from 1.33 to 1.90).[12,24,25] A study of 170 children with asthma who received an in-home intervention demonstrated reduced health care utilization and an annual net savings of about $821 304,[11] and another study showed a net savings of $26 720 per 100 participants.[13]

The costs associated with asthma are large, estimated at $56 billion annually in 2007, suggesting that savings from effective interventions can also be large if implemented broadly.[26] Although costs associated with lost days of school and work and premature death contribute to these totals, health care costs are the primary contributing factor. Annually, direct medical costs for the 22 million US children and adults with asthma are $1004 and $2077, respectively, more than those for children and adults without asthma.[27,28]

Control of housing and environmental factors is a key component of asthma control clinical guidelines but is often difficult to achieve within the clinical setting.[29] Multiple studies and programs have reported that home-based asthma interventions produce a significant reduction in emergency department (ED) visits, hospitalizations, days with worsening asthma, days of school or work missed because of asthma, improvements in use of medications, use of asthma action plans, knowledge of personal asthma triggers, and how to avoid or reduce exposure to common triggers.[21,30,31] Despite this evidence, these interventions have not been broadly implemented. This may be due, in part, to a lack of political will and inadequate collaboration between housing and health economic sectors,[32] but concerns about the generalizability of the evidence base also present a barrier. For example, most previous studies have included several hundred subjects at most, are focused on children in low-income urban households, have short follow-up periods, or provide the same degree of intervention regardless of asthma severity.

The economic studies have had differing degrees of data quality and economic analysis, although at least 2 studies have rated economic asthma data to be between fair and good.[23,33] Studies have produced economic results that vary with the frequency and number of home visits, type of professional staff, range of home improvement, and supplies provided. In addition, most economic studies on asthma have analyzed costs and benefits borne by society, including but not limited to those associated with the health sector. While this societal perspective is appropriate for public health professionals, there is also a need for studies that rely on a narrower payer perspective, focusing on the savings that accrue directly to the entity paying for the service (eg, a state Medicaid agency).

These gaps and variations in the evidence base may undermine confidence among health care payers that home-based interventions can be brought to scale successfully. This article aims to fill some knowledge gaps by using a payer perspective to examine economic costs and benefits associated with providing home-based asthma interventions on a large scale. The New York State (NYS) Healthy Neighborhoods Program (HNP)[34] examined here addresses asthma as part of a comprehensive healthy homes approach. It is a useful model because of its scale (in 2015, it served almost 7000 homes, 18 000 adults and children, and 2400 individuals with asthma), reaches different types of housing, and has operated in 10 to 15 urban and rural counties. Using nonclinical staff, the interventions are tailored to the condition of the dwelling and the needs of its residents.

Methods

Program description

The NYS Department of Health (DOH) funds county health departments to provide in-home assessments and interventions to improve the environmental health and safety of residents in selected high-risk communities. Trained environmental health specialists (sanitarians, health educators, public health nurses, or other public health professionals) provide the intervention, which varies in scope according to the needs identified during the assessment and the expertise of the staff. To identify homes for an initial visit, the programs use door-to-door canvassing and referrals from other programs, organizations, or health care providers. Roughly a quarter of all households are revisited 3 to 6 months after the initial visit. Revisits are prioritized on households with a resident with asthma, but the timing and selection of households for revisit are determined by each program. We describe the program in detail in a separate article.[35]

During the initial visit, the surveyor visually identifies health and safety hazards and provides residents with guidance, products, and referrals to address the hazards. For example, if cockroaches are found, the surveyor may educate the family about reducing food and water sources, provide low-cost products (eg, gel baits or containers to store food and garbage), and make referrals to other services (eg, integrated pest management, professional cleaning). The surveyor also interviews each person with asthma or an adult proxy about asthma symptoms, health care utilization, and asthma management. A certified asthma educator may provide more detailed information and education than a sanitarian, but all surveyors can provide pamphlets and a blank asthma action plan, explain potential asthma triggers in the home and steps to reduce or eliminate exposure, distribute low-cost products to address triggers, provide referrals to services, reinforce basic self-management messages, and share information about the New York Health Insurance Exchange.

Study sample

Thirteen counties were funded during 2008-2012 and 10 continuously. The staff conducted asthma assessments for 8813 residents who had been told by a health care professional that they had asthma. Of these, 2284 (26%) were revisited. We excluded 273 children 0 to 4 years old (asthma is difficult to diagnose in this age group) and 10 children missing age, leaving 2001 persons. To compare the impact of targeting the intervention with residents with more poorly controlled asthma, we created 2 groups: the asthma events group (representing individuals with more poorly controlled asthma) and the active asthma group. We defined asthma events as an asthma attack in the past 3 months and/or 1 or more medical encounters in the past 12 months for an asthma attack or worsening symptoms, including an ED or urgent care visit, health care professional visit, and/or a hospital stay. Individuals reporting 1 or more of these events at the initial visit were assigned to the asthma events group (n = 1616). The active asthma group (n = 1963) includes the asthma events group plus individuals who did not have any medical encounters but reported use of either a quick relief (QR) medication or a controller medication. This corresponds most closely to the Centers for Disease Control and Prevention's definition of active asthma.[36] Finally, to minimize re-reporting of events resulting from a large overlap in the 12-month recall period and the correlation between the benefit and interval, we selected individuals with the revisit 91 to 365 days after the initial visit, giving 1281 persons in the active asthma group and 999 in the asthma events group. The program evaluation of the HNP was reviewed by the institutional review board of the NYS DOH and given exempt status on the basis of not being research.

Program cost estimates

The HNP provides a framework of core operating procedures that are consistent across all of the county programs; however, the counties are encouraged to build on local resources and infrastructure to deliver services that are meaningful and effective for each community. These variations result in a range of costs of providing the asthma intervention. We conducted a cost estimation study to estimate the average cost of an HNP visit. Costs include salaries and fringe benefits for staff (whether paid or not by state funding), travel, and products. The study was conducted in 4 counties that are representative of the scope, geography, and administration of the program. We worked with each county to develop a daily time record worksheet for each job title (eg, public health educator, supervisor, administrator). Each worksheet included the following activities: time spent on visits, travel, office work (eg, processing paperwork, preparing budgets and reports, purchases), community outreach, staff meetings, and products and materials. Each county selected two 2-week study periods (10 business days), one each in the spring and fall, when staffing was at a maximum and activities would be typical. The staff were trained in advance of the data collection. The NYS DOH staff reviewed the worksheets for completeness and gathered salary information and typical costs associated with travel and products provided. Products and educational materials obtained at no cost were not included in the overall cost of the program.

The cost per asthma visit was the sum of 6 expenditure categories:

1. Cost of the standard healthy homes visit: total salary cost of general activities and travel (minutes × salary per minute) conducted by the field staff divided by the total number of home visits.
2. Additional cost of asthma visits: salary cost of time spent conducting the asthma visit (minutes × salary per minute) divided by the number of homes where at least 1 resident with asthma was evaluated.
3. Administrative costs of a home visit: salary cost of the administrative staff divided by the total number of visits conducted by the field staff.
4. Cost of travel: the number of miles traveled multiplied by travel reimbursement, divided by the

total number of visits. (Asthma visits were not calculated separately because home visits and asthma visits are often conducted on a single trip.)
5. Cost of standard products provided at all home visits: total cost of purchasing products divided by the total number of home visits.
6. Cost of asthma-specific products: total cost of purchasing products divided by the number of asthma visits.

The final estimated cost per asthma visit is the sum of the 6 expenditure categories.

Program benefits

During HNP visits, assessment, and intervention, information is collected using a standardized asthma assessment form (see documents, Supplemental Digital Content 1, available at: http://links.lww.com/JPHMP/A289). For this analysis, we used the following self-reported data on medical encounters and medication use:

1. Number of visits to a doctor or other health care professional for worsening asthma or an asthma attack in the past 12 months.
2. Number of visits to an ED or urgent care center because of asthma in the past 12 months.
3. Number of overnight stays in the hospital because of asthma in the past 12 months.
4. Has a prescription for QR medicine and, if yes, the number of times QR medicine was used in the past week.
5. Has a prescription for daily controller medicine and, if yes, took it every day in the past week.

For medical encounters (points 1-3), the change in encounters is the number reported by an individual at the initial visit (preintervention) minus the number reported at the revisit (postintervention). Because the recall period (12 months) was longer than the interval between the initial visit and revisit, we calculated an annualized change that takes into account the time between the visits (see Document, Supplemental Digital Content 1, available at: http://links.lww.com/JPHMP/A289). We assumed one uniform distribution for encounters during the 12 months before the initial visit and another for encounters during the 12 months after the initial visit. To minimize the effects of outliers, values below the 1st percentile and above the 99th percentile were replaced by the values at the 1st and 99th percentiles, respectively (Winsorization). For medication use (points 4 and 5), we identified the group of residents with asthma who had a prescription for a QR medication, at either the initial or the revisit, and the group that had a controller medication at either visit. The change is the proportion that reported using a QR medication in the past week at the initial visit minus the proportion at the revisit. For controller medications, the change is the proportion that had used the controller every day in the past week at the initial visit minus the proportion at the revisit.

The NYS Office of Health Insurance Programs provided the authors with the total cost in 2010 for asthma-related services and medications filled for Medicaid enrollees covered by managed care organizations. The average cost per person receiving the service was $265 for outpatient visits, $250 for ED visits, and $8667 for hospital stays. For medications, the average cost per enrollee (whether or not a person filled a prescription) was $145 for QR medications and $980 for controller medications. The benefit in dollars is the mean change in the medical encounter or medication use multiplied by the average cost of the medical encounter or prescription.

The benefit to cost ratio is the benefit (the change in the health care utilization) divided by the cost of an HNP asthma visit. A ratio greater than 1.0 represents the proportion of savings (averted expenditures) after the HNP asthma intervention. We calculated the ratio for all medical encounters and medications combined, as well as for each medical encounter and medication, for medical encounters combined, and for medication use combined.

Results

Because the asthma events group is a subset of the active asthma group, the following summary is for the asthma events group (Table 1). The primary respondents were 57% white (similar to 2 programs in urban areas and much lower than the 2 rural and semirural counties), 69% of households received some public assistance, and 41% of adults were smokers. Sixty-nine percent of dwellings were built before 1950 and another 20% were built between 1950 and 1978.

Tables 2 and 3 present summary statistics for the number of medical encounters and medication use, respectively. The following summary is for the asthma events group. Persons in the asthma events group reported significant reductions in the number of visits to health care professionals, ED/urgent care, and hospital stays. At the initial visit, the mean number of visits to a health care professional was 2.6 per year and 2.0 per year at the revisit, with a mean decrease of 1.6 per year ($P < .001$). For visits to an ED or urgent care, the mean number went from 0.7 per year to 0.6 per year, a mean decrease of 0.5 per year ($P < .001$), and

TABLE 1
Demographic Characteristics of the Active Asthma Group[a] and the Asthma Events Group[b]

Demographic Characteristics	Active Asthma Group (N = 1281) n	Active Asthma Group (N = 1281) %	Asthma Events Group (N = 999) n	Asthma Events Group (N = 999) %
Homes				
Number of homes	1000	…	791	…
Number of residents with asthma per home				
1	800	80	635	80
2	140	14	116	15
3+	60	6	40	5
1-5 units in the building	890	89	703	89
Home is rented or owned				
Owned	320	32	248	31
Private rental	609	61	485	61
Public rental	70	7	58	7
Age of building				
Before 1950	654	69	512	68
1950-1978	195	20	159	21
After 1978	105	11	87	11
Primary respondent				
Race (not mutually exclusive)				
White	569	57	447	57
Black	379	38	296	37
Other	14	1	13	2
Hispanic ethnicity	125	13	105	14
Has high school diploma or equivalent	739	77	587	77
Household receives public assistance	680	69	565	72
Residents with asthma				
Age, y				
5-9	184	17	154	18
10-14	135	12	106	12
15-17	62	6	49	6
18-24	85	8	68	8
25-44	245	22	198	23
45-64	274	25	207	24
65+	127	11	78	9
Adults				
Females	559	77	434	79
Smokers	300	41	225	41
Children				
Females	231	42	184	41

[a] *Active asthma group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to emergency department, or hospital stay) and/or used a quick relief and/or controller medication.*
[b] *Asthma events group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to emergency department, or hospital stay).*

for hospital stays, the mean decrease was 0.1 per year ($P = .003$).

Ninety-four percent of persons in each asthma group reported having a prescription for a QR medication at one or both visits (Table 3). In the asthma events group, 58% reported using their QR medication at least once in the past week and 48% at the revisit. For controller medications, at the initial

TABLE 2
Mean Number of Medical Encounters and Annualized Change After the Intervention for the Active Asthma Group[a] and the Asthma Events Group[b]

Medical Encounters by Group	Mean Number at Initial Visit	Mean Number at Revisit	Mean Annualized Change[c]	Mean Annualized Change Winsorized[d]	*P* (*t* Test Winsorized Change)
Active asthma group (N = 1281)					
Visits to health care professional	2.0	1.6	1.2	1.2	<.001
Visits to ED or urgent care	0.6	0.5	0.3	0.4	<.001
Hospital stays	0.3	0.2	0.3	0.1	.008
Asthma events group (N = 999)					
Visits to health care professional	2.6	2.0	1.7	1.6	<.001
Visits to ED or urgent care	0.7	0.6	0.5	0.5	<.001
Hospital stays	0.4	0.3	0.4	0.1	.003

Abbreviation: ED, emergency department.
[a] *Active asthma group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to ED, or hospital stay) and/or used a quick relief and/or controller medication.*
[b] *Asthma events group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to ED, or hospital stay).*
[c] *Because the recall period of 12 months is longer than the interval between visits, we calculated the annualized change (ie, an estimate of the change if the visits had been 12 months apart).*
[d] *Winsorization: Values below the 1st percentile and above the 99th percentile were reassigned to the value of the 1st percentile and 99th percentile, respectively.*

visit, 83% of persons in the asthma events group reported taking their medication every day in the past week and 83% at the revisit in the active asthma group.

Table 4 presents the benefit and cost analysis. The highest average cost of an asthma visit among the 4 estimates was $302. For the 4 counties combined, the average percentage that each expenditure category contributed to the cost of an asthma visit was 13% for the cost of labor of an asthma assessment and intervention; 3% for mileage to and from an asthma visit; 27% for products provided at an asthma visit; 34% for administrative costs (including the cost of administrative and office activities and office supplies); and

TABLE 3
Number and Proportion Using an Asthma Medication and Change After the Intervention for the Active Asthma Group[a] and the Asthma Events Group[b]

	Active Asthma Group (N = 1281)		Asthma Events Group (N = 999)	
Self-reported Medication Use by Group	n	%	n	%
Had a quick relief prescription at either visit	1205	94	942	94
Used medication at least once in past week				
Initial visits	910	63	530	58
Revisits	786	54	448	48
Change (% initial visit − % revisit)[c]		9		10
Had controller medication prescription at either visit	932	73	692	69
Took medication every day in the past week				
Initial visits	679	79	522	83
Revisits	696	81	539	83
Change (% initial visit − % revisit)[c]		−2		0

[a] *Active asthma group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to emergency department, or hospital stay) and/or used a quick relief and/or controller medication.*
[b] *Asthma events group: persons at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to emergency department, or hospital stay).*
[c] *A positive (negative) value indicates a decrease (increase) in the proportion of persons who used the medication in the past week.*

TABLE 4

Benefit to Cost Ratios for Medical Encounters and Medication Fills/Refills, Based on the $302 Estimated Cost per Asthma Visit for Asthma Events Group[a] and Active Asthma Group[b]

		Active Asthma Group (N = 1281)			Asthma Events Group (N = 999)		
Medical Encounters/Medication Use	Cost of Health Care Utilization[c]	Change in Health Care Utilization	Benefit[d]	Benefit to Cost Ratio	Change in Health Care Utilization	Benefit[d]	Benefit to Cost Ratio
Medical encounters							
Visits to health care professional	$97	1.17	$113	0.37	1.61	$156	0.52
Visits to ED or urgent care center	$180	0.36	$65	0.22	0.49	$88	0.29
Hospital stays	$6866	0.09	$618	2.05	0.12	$824	2.73
Medical encounters combined	…	…	$796	2.64	…	$1068	3.54
Medication use							
Used QR medications in past 7 d	$145	0.09	$13	0.04	0.10	$15	0.05
Use controller medications every day in the past 7 d	$980	− 0.20	− $196	− 0.65	0.00	$0	0.00
Medications combined	…	…	− $183	− 0.61	…	$15	0.05
Medical encounters and medication use	…	…	$613	2.03	…	$1083	3.58

Abbreviations: ED, emergency department; HNP, Healthy Neighborhoods Program; QR, quick relief.

[a] *Active asthma group: persons with at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to ED, or hospital stay) and/or used a QR and/or controller medication.*

[b] *Asthma events group: persons at least 1 of 4 asthma events (asthma attacks, visit to health care professional, visit to ED, or hospital stay).*

[c] *Average cost per person based on New York State Medicaid encounter data.*

[d] *A positive dollar benefit represents a cost savings after the HNP asthma intervention. The benefit to cost ratio = benefit ($)/$302 estimated cost of an asthma visit.*

23% for fringe benefits (data not shown). The average cost of health care utilization in 2010 was $97 for a visit to a health care professional, $180 per ED visit, $6866 per hospital stay, $145 for QR medications, and $980 for controller medications. For the asthma events group, the highest benefit in dollars (ie, cost savings) was $824 per hospital stay, followed by $156 for visits to a health care professional, $88 for ED visits, and $15 for medications, for a total savings of $1083 per asthma visit. This gives a benefit to cost ratio of 3.58 and an average net savings of $781 ($1083 − $302). For the active asthma group, the benefit was $613, the benefit to cost ratio was 2.03, and the net savings was $311.

Discussion

This analysis confirms that the economic benefits of home-based environmental asthma interventions outweigh the costs. It adds evidence for the impact on previously understudied populations, including adults with asthma and rural communities. It also underscores the potential for increased benefits when services are targeted to residents with poorly controlled asthma. Most importantly, benefits are realized even when the intervention is deployed on a large scale, using nonclinical staff and when a narrow, public payer perspective is used for calculating potential benefits.

Like previous studies,[23] some health care costs (notably prescription medications) increased after the intervention. The benefits indicate that health care savings were largely driven by the decrease in hospitalizations. The benefits realized by the NYS HNP were more modest than those reported by the Community Guide to Preventive Services: $5 to $14 returned for every $1 invested compared with our findings of $2.03 to $3.58 benefit for every $1 invested. It is possible that, while we focused exclusively on health care utilization, other studies relied on a societal perspective that monetizes social benefits, such as missed school days or symptom-free days. Compared with more recent studies,[12,24,25] both the asthma events group and the active asthma group had a slightly greater benefit to program cost ratios. This may be due to differences in the populations served and program design. The cost of the HNP's low-intensity, single-visit approach is very modest. Many programs provide the intervention over multiple visits, conduct follow-up visits for all participants, and provide more intense services (eg, professional cleaning, integrated pest management) and remediation (eg, carpet removal, repair of leaks). These differences in program design can increase costs as well as the magnitude of the benefits. That is, a payer seeking to implement a program that provides a follow-up visit to all participants may see not only a slight increase in costs but also a slight increase in benefits associated with the extra opportunity to reinforce environmental messages. More importantly, a payer need not rely on externalized social benefits (eg, lost school days) to realize a significant financial improvement in the bottom line for asthma care.

Strengths and limitations

This evaluation is important and unique, particularly due to its large sample size, geographically diverse population, inclusion of adults with asthma, use of nonclinical staff, and use of a payer perspective. The payer perspective estimates the benefits that apply to investors from the health care sector. The evaluation also provides support for taking asthma home-based services to scale in real-world settings in order to reduce medical costs borne by health care payers.

The relatively short follow-up period prevents an examination of long-term sustainability of benefits. Conversely, the low-intensity approach and the short follow-up period are likely more relevant for services offered at scale through the health care sector. The overlap in recall period for key asthma outcomes posed a challenge for pre- and postintervention comparisons, but we attempted to correct for the overlap. Another important limitation is the lack of a comparison group, which precludes attributing the entirety of the observed improvements to the intervention. However, the analysis compared impacts across groups of patients and showed the expected increase in benefits for patients with more poorly controlled asthma.

Because of the flexible protocol, there are differences in the way that the programs or staff assess homes and conduct interventions. While this is advantageous for providing services that address a range of challenges faced by residents in HNP communities (including housing conditions, occupant behaviors/attitudes, available resources), our findings may not be representative of communities elsewhere. In addition, aggregating findings across the counties may mask geographic variation in housing conditions, improvements, and operating costs. Therefore, to avoid overestimating the potential benefits, we used the highest cost per asthma visit among the 4 programs that participated in the time estimation study. This conservative approach was also important because the program costs reported do not include supplies or services that were obtained at no cost or provided by the resident or property owner (eg, costs of repairs or ongoing pest management). Similar services offered through the health care sector may incur different costs due to differences in staffing, program

design, age and quality of housing stock, or ability to obtain products and services at low or no cost. At the same time, the use of Medicaid-managed care costs to estimate health care utilization spending and savings may underestimate the potential benefit of the intervention. This analysis suggests that avoided hospitalizations may be a large driver of savings on a population level, and in 2011, NYS reported that among all sources of payment, Medicare had the highest average cost of $25 227 for asthma hospitalizations, followed by other third party or private insurance ($16 725), Medicaid ($14 633), and self-pay ($11 382). While a majority of households reported being eligible for public assistance, and therefore are likely to be eligible for Medicaid in NYS, the analysis was not adjusted to reflect the higher cost of other potential payment sources. Finally, the benefits of this intervention are likely underestimated, as the intervention (and associated costs) addresses a range of health and safety hazards in the home, but only improvements in asthma outcomes were monetized. The actual cost to benefit ratio may be much higher.

Sources of bias include selection bias (which homes allow access and which are targeted for revisit), recall bias (resident reporting of exposure to triggers following an ED visit), social desirability bias (residents may not be forthcoming about issues such as tobacco use or presence of cockroaches), and reporting bias (surveyors' subjectivity in evaluating their own work at the revisit). However, having a different surveyor at the revisit did not change the outcomes (data not shown) and the impact of social desirability bias is mitigated by a reliance on visual assessment (eg, the presence of ashtrays outweighs a statement that no smoking occurs in the home). Finally, there were significant reductions in the Winsorized annualized number of visits to health care professionals, ED/urgent care, and hospital stays for both groups. Although Winsorizing is a robust method of lessening the effects of outliers, it dampens the effects of extremely high and low changes on the means.

Conclusion

Low-intensity, home-based, environmental interventions for people with asthma decrease the cost of health care utilization, and greater reductions are realized when services are targeted toward people with more poorly controlled asthma. Benefits can be realized for both children and adults with asthma, in urban and rural settings, and when using a narrow payer perspective that does not include societal benefits. Availability of a workforce capable of conducting a visual assessment and providing an environmental intervention is often perceived as a barrier to large-scale implementation and as such this program's reliance on nonclinical staff and a low-intensity approach is notable. While this approach may produce benefits that are more modest than higher-intensity approaches, it may also be more feasible to implement on a large scale and in a variety of communities. Future evaluations should focus on collecting more detailed data on asthma outcomes and program costs and articulating the impact of differences in program design, intensity, and scale on health care utilization and program costs.

Implications for Policy & Practice

- For health care payers, and public payers in particular, this article adds to the evidence base that home-based environmental interventions can shift costs from treating worsening asthma to controlling it and reduce overall health care utilization costs.
- Payers should consider expanding coverage, at least for patients with poorly controlled asthma or who may be at risk for poor asthma control, to include services that address triggers in the home environment.

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