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Original Article

Green & Healthy Homes Initiative: Improving Health, Economic, and Social Outcomes Through Integrated Housing Intervention

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ABSTRACT

Poor quality housing is an ongoing environmental injustice placing a significant burden on low-income and minority families. The Green & Healthy Homes Initiative (GHHI) in Baltimore, MD, grew out of the historical healthy homes work of the Coalition to End Childhood Lead Poisoning, an organization dedicated to using housing as a platform for health to ensure environmental and social justice for families and children in low-income communities. GHHI's Healthy Homes Demonstration Project utilized the standards and practices created by GHHI: A Holistic Housing Assessment coupled with environmental health education and combined as an integrated environmental health and energy housing intervention for children with asthma, ages 2–14. The project braids resources from healthy homes, lead hazard reduction, weatherization, and energy efficiency projects to form a single multi-component, multi-factorial intervention. Findings from the health surveys at intake and six months after the intervention provide evidence of the impact on the reduction of asthma symptomatic episodes, emergency room visits, and hospitalizations, while showing improvements in school attendance and parents' work attendance. Findings will provide evidence that improved health outcomes and more stable and productive homes in primarily African American, low-income neighborhoods are related to the mitigation of asthma triggers and home-based environmental health hazards. Upstream integrated housing interventions are an effective means to improve health, economic, and social outcomes for children diagnosed with asthma.

INTRODUCTION

As a consequence of collective macro-socioeconomic activities producing negative externalities and unhealthy geographies, environmental injustice causes disadvantaged families to live where environmental, social, and health risks are concentrated in what are defined as ''riskscapes.''[1] The majority of the residents living in such riskscapes are both medically underserved and overburdened by the consequences of unhealthy housing. As a result, a disproportionate burden of housing-related hazards impact low-income persons and minorities, who are more likely to lack resources to prevent or mitigate residential problems that negatively impact health.[2] Families and children exposed to greater home-based health risk and a greater burden of disease are presented with a double disparity: disparities related to poor quality housing and poverty that contribute to greater health inequities.[3] In general there is a long term affordable housing shortage because American housing markets produce low cost housing units through a process called filtering,

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[1]Sacoby Wilson, ''An Ecologic Framework to Study and Address Environmental Justice and Community Health Issues,'' *Environmental Justice* 2 (2009): 15–24. R. Morello-Frosch and R. Lopez, ''The Riskscape and the Color Line: Examining the Role of Segregation in Environmental Health Disparities,'' *Environ Res* 102 (2006): 181–196. R. Morello-Frosch, M. Pastor and J. Sadd, ''Environmental Justice and Southern California's 'Riskscape': The Distribution of Air Toxics Exposures and Health Risks among Diverse Communities,'' *Urban Affairs Review* 36 (2001): 551–578.

[2]U.S. Department of Housing and Urban Development (HUD), Healthy Homes Strategic Plan. (HUD, 2009).

[3]S. Wilson, H. Zhang, C. Jiang, et al., ''Being Overburdened and Medically Underserved: Assessment of this Double Disparity for Populations in the State of Maryland,'' *Environmental Health* 13 (2014): 26.

where existent housing units drop in cost as their relative quality falls, rather than through construction of new, lower cost units.[4] For decades most urban housing markets in the United States have failed to produce an adequate supply of quality affordable housing for low-income households.[5] This legacy of poor quality housing is a major contributing cause of environmental injustice and health inequities for many low-income American families.

Recently, the long-term affordable housing shortage has worsened as a result of the Great Recession, which resulted in high unemployment, declining rates in home-ownership, and greater disinvestment in minority and low-income neighborhoods.[6] Lower income families occupy many of the nearly 30 million American homes with structural damages, elevated levels of lead hazards, and radon or environmental contaminants that place them at risk for injuries and acute or chronic illnesses.[7] Thus, constrained by a limited supply of affordable quality housing and the limited resources that families bring to market, low-income households are systematically exposed to poor quality housing, which is a known social determinant of health and economic inequalities.[8]

In addition, households of low socioeconomic status are more vulnerable to the impacts of high energy burden and, on average, pay a greater proportion of their income on residential energy, especially when compared to non-low-income households, 13.5% versus 3.6%, respectively.[9] A high residential energy burden drives up housing costs, making them unaffordable, and often leads to increased social inequalities such as fuel poverty, utility-related debt, and poor health caused by energy and food insecurity.[10] Energy insecurity causes families to experience greater utility debt, shut-offs, and trade-offs concerning the allocation of household expenditures.[11] Many families, in particular low-income and minority households, have been negatively impacted by an increasing housing burden caused by rising energy costs.

The Green & Healthy Homes Initiative (GHHI) addresses the lack of affordable quality housing by employing an innovative model of comprehensive home assessment and integrated interventions to both improve deteriorated housing and to use housing as a platform for improved health, economic, and social outcomes for low-income families. By incorporating proven environmental health and safety interventions (to reduce housing related-health costs of asthma, lead poisoning, and injury) with weatherization and energy efficiency measures (to reduce costly energy consumption), GHHI has demonstrated positive synergistic impacts for vulnerable populations such as children with asthma.[12]

The comprehensive environmental assessment is based on the Eight Elements of a Green & Healthy Home (dry, clean, pest-free, safe, contaminant-free, well-ventilated, well-maintained, and energy-efficient) as supported by the U.S. Department of Housing and Urban Development–Office of Lead Hazard Control and Healthy Homes (HUD) and the Centers for Disease Control and Prevention (CDC) and is combined with technical energy audits to identify cost-effective weatherization measures. Implementation of the GHHI model improves the overall physical condition of homes, supports positive social outcomes by lessening housing burdens, and provides a standard to certify

[4]F. J. Moumen, ''American Housing Survey A Measure of (Poor) Housing Quality.'' (U.S. Department of Housing and Urban Development Office of Policy Development and Research prepared by Econometrica, Inc.). R. J. Feldman, ''The Affordable Housing Shortage: Considering the Problem, Causes and Solutions.'' (Federal Reserve Bank of Minneapolis, Bank and Policy Paper, 2002).

[5]K. Wardrip, ''Housing Affordability Trends for Working Households: Affordability Worsens Despite Decline in Home Prices.'' (Center for Housing Policy, Washington, D.C., 2009).

[6]Harvard Joint Center for Housing, *The State of the Nation's Housing 2012*. (Harvard, 2012).

[7]HUD, ''Advancing Healthy Housing: A Strategy for Action.'' <http://portal.hud.gov/hudportal/documents/huddoc?id=AHHASA_2-19.pdf> (retrieved March 30, 2013, from U.S. Department of Housing and Urban Development).

[8]Healthy People 2020, ''Healthy People 2020: An Opportunity to Address the Societal Determinants of Health in the United States.'' (Secretary's Advisory Committee on Health Promotion and Disease Prevention Objectives for 2020; Washington D.C. July 2010). WHO. Report on the Technical Meeting on Quantifying Disease from Inadequate Housing, <http://www.euro.who.int/__data/assets/pdf_file/0007/98674/EBD_Bonn_Report.pdf> (retrieved January 11, 2012, from World Health Organization). P. Sharkey, ''Residential Mobility and the Reproduction of Unequal Neighborhoods,'' *Cityscape: A Journal of Policy Development and Research* (2012).

[9]American Coalition for Clean Coal Electricity (ACCCE). Energy Cost Impacts on American Families, 2001–2012. <http://www.americaspower.org/sites/default/files/Energy_Cost_Impacts_2012_FINAL.pdf> (retrieved April 2, 2013, from ACCCE).

[10]J. N. Harkness et al., ''Housing Affordability and Children's Well-Being: Evidence from the National Survey of America's Families,'' *Housing Policy Debate* 16 (2005): 223–55. M. G. Kushel et al., ''Housing Instability and Food Insecurity as Barriers to Health Care Among Low Income Americans,'' *Journal of General Internal Medicine* 21 (2006): 71–7. J. Cook et al., ''A Brief indicator of Household Energy Security: Associations with Food Security, Child Health and Child Development in US Infants and Toddlers,'' *Pediatrics* 21 (2008): e867–e875. D. A. Frank, et al., ''Heat or Eat: The Low Income Home Energy Assistance Program and Nutritional and Health Risks Among Children Less than 3 Years of Age,'' *Pediatrics* (2006): e1293–e1301. D. Hernandez, ''Energy Insecurity: A Framework for Understanding Energy, the Built Environment, and Health Among Vulnerable Populations in Context of Climate Change,'' *American Journal of Public Health* (2013): e1–e2.

[11]D. Hernandez and S. Bird, ''Energy Burden and the Need for Integrated Low-Income Housing and Energy Policy.'' *Poverty & Public Policy,* (2010), 24: 5–25.

[12]U.S. Department of Health and Human Services (HHS). The Surgeon General's Call to Action To Promote Healthy Homes. <http://www.surgeongeneral.gov/library/calls/healthyhomes/calltoactiontopromotehealthyhomes.pdf> (retrieved April 2, 2013, from U.S. Department of Health and Human Services). HUD. Advancing Healthy Housing: A Strategy for Action. <http://portal.hud.gov/hudportal/documents/huddoc?id=AHHASA_2-19.pdf> (retrieved March 30, 2013, from U.S. Department of Housing and Urban Development).

sustainable investments in communities in order to maintain low-cost quality housing.[13]

DISCUSSION

GHHI Healthy Homes Demonstration Project targets pediatric asthma problem in Baltimore

Childhood asthma has reached almost epidemic levels, presenting a disparate amount of disease burden on low-income families in urban communities.[14] In Baltimore, disparities among the lowest income earners (household median income < $15,000 per year) and the highest income earners (household median income ≥ $75,000 per year) are persistent in childhood asthma (ratio 2.76:1).[15] Mitigating exposure to indoor asthma triggers, contaminants, and health hazards contributes to ongoing efforts to reduce chronic disease outcomes for households of low-socioeconomic status, which are disproportionately burdened by the negative effects. Social justice in the context of human health is generally equated with access to health resources and equal opportunity to a healthy life. Determinants for domestic health disparities (health outcomes that impact certain populations to a greater extent than others) have been identified and integrated into social programs, such as this project, tasked with combatting chronic disease in the U.S.[16] From 2010–2013, the HUD-funded GHHI Healthy Homes Demonstration Project targeted a population of low and very-low income children, ages 2–14, in Baltimore diagnosed with asthma. The innovation is the delivery of environmental health services to address asthma exacerbations at the primary source of the problem, the home.

Historically, Baltimore has consistently fared worse than the rest of Maryland and the nation on many health indicators such as infant mortality, heart disease, and asthma.[17] The urban environment, especially the built environment of a home, presents multiple risk factors which are known to trigger or exacerbate the asthmatic condition in children.[18] As a social determinant of health, housing deficiencies present proximal conditions that have been strongly associated with allergen sensitization and asthma exacerbation.[19] Many low-income residents in the affordable housing market are still subject to unnecessary environmental risks in the home involving exposures related to physical, chemical, biological, and design factors.[20] Deteriorated housing conditions, which often present multiple deficiencies, when coupled with low social cohesion in the neighborhood, have been found to result in significantly elevated odds of asthma prevalence.[21] The Baltimore City Health Department estimated an 18% lifetime prevalence of asthma for children in 2006, which was above the state of Maryland (13.1%) and national (12%) prevalence rates.[22] Moreover, the fact that African American residents of Baltimore have significantly higher rates (6.5 times higher compared to whites) of asthma emergency department (ED) visits identifies asthma as a health issue which is an increasing health disparity for African American children and families.[23] Under this project, GHHI delivered in-home asthma education and tailored environmental control practices, combining best practices of Healthy Homes with weatherization and energy efficiency activities to retrofit properties.

[13]D. E. Jacobs, ''Environmental Health Disparities in Housing,'' *American Journal of Public Health* 101 (2011): S115–122. X. Bonnefoy, ''Inadequate Housing and Health: An Overview,'' *International Journal of Environmental Pollution* (2007): 411–429. H. C. Granade et al., Unlocking the Energy Efficiency in the US Economy. <http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/unlocking_energy_efficiency_in_the_us_economy> (retrieved March 30, 2013, from McKinsey & Co.).

[14]W. J. Morgan et al., ''Results of a Home-Based Environmental Intervention among Urban Children with Asthma,'' *New England Journal of Medicine* (2004): 1068–1080. E. C. Matsui, ''Asthma in Inner City and the Indoor Environment'' *Immunology and Allergy Clinics of North America* (2008): 665–686.

[15]Baltimore City Health Department (2014). Health Disparities Report Card. <http://health.baltimorecity.gov/sites/default/files/Health%20Disparities%20Report%20Card%20FINAL%2024-Apr-14.pdf> (retrieved September 11, 2014, from Baltimore City Health Department, Office of Epidemiologic Services).

[16]Center for Medicaid and CHIP Services (CMCS) Informational Bulletin, 2013.

[17]Baltimore City Health Department. Health Disparities Report Card. <http://health.baltimorecity.gov/sites/default/files/Health%20Disparities%20Report%20Card%20FINAL%2024-Apr-14.pdf> (retrieved September 11, 2014, from Baltimore City Health Department, Office of Epidemiologic Services). Maryland Asthma Control Program. Maryland Asthma Control Plan: An Action Agenda to Reduce the Burden of Asthma in Maryland 2010–2015. <http:/www.marylandasthmacontrol.org> (retrieved September 1, 2014).

[18]N. N. Hansel, P. A. Eggleston, J. A. Krishnan, J. Curtin-Brosnan, C. S. Rand, C. M. Patino, et al., ''Asthma-Related Health Status Determinants of Environmental Control Practices for Inner-City Preschool Children,'' *Annals of Allergy, Asthma, & Immunology* (2006): 409–417.

[19]S. K. Ahluwalia, ''The Indoor Environment and its Effects on Childhood Asthma,''*Current Opinion in Allergy and Clinical Immunology* (2011): 137–143. D. W.-H. Brugge, ''Association and Correlation of Self-Reported Home Environmental Factors and Health Symptoms.''*Archives of Environmental & Occupational Health* (2006): 33–41. G. B. Diette, ''Home Indoor Pollutant Exposures among Inner-City Children With and Without Asthma.''*Environmental Health Perspectives* (2007): 1665–1669. M. C. McCormack, ''Common Household Activities Are Associated with Elevated Particulate Matter Concentrations in Bedrooms of Inner-City Baltimore Pre-School Children.'' *Environmental Research* (2008): 148–155. M.C. McCormack, ''Indoor Particulate Matter Increases Asthma Morbidity in Children with Non-atopic and Atopic Asthma.''*Annals of Allergy, Asthma & Immunology* (2011): 308–315. D. A. Rao, ''Impact of Environmental Controls on Childhood Asthma.'' *Current Allergy and Asthma Reports* (2011): 414–420. J. M. Gaffin, ''The Role of Indoor Allergens in the Development of Asthma.''*Current Opinion in Allergy and Clinical Immunology* (2009): 128–135.

[20]C. S. Mitchell, ''Current State of the Science: Health Effects and Indoor Environmental Quality,'' *Environmental Health Perspectives* (2007): 958–964.

[21]E. Rosenbaum, ''Racial/Ethnic Differences in Asthma Prevalence: The Role of Housing and Neighborhood Environments.'' *Journal of Health and Social Behavior* (2008): 131–145.

[22]Baltimore City Health Department. Asthma in Baltimore City. <http://www.baltimorehealth.org/info/Asthma_BaltimoreCity_2008.pdf> (retrieved January 5, 2012, from A –Z Index of Baltimore Data Sources by Health Topic).

[23]*Ibid.*

Table 1. Socio-demographic Characteristics of Healthy Homes Demonstration Participants

	Characteristics	*Frequencies number (%)*
Gender	Female	132 (94.2)
	Male	8 (5.8)
Age group	18–25	19 (13.8)
	26–35	44 (31.9)
	36–45	27 (19.6)
	46–55	34 (24.6)
	Over 55	14 (10.1)
Race	American Indian /Alaskan Native	1 (0.8)
	Black/African American	128 (93.4)
	White	8 (5.8)
	Hispanic	0
	Asian	0
Education	Less than high school diploma	27 (19.5)
	High school diploma or GED	48 (34.5)
	Some college/trade school/AA degree	47 (33.8)
	Bachelor or post g raduate degree	17 (12.3)
Employment	Full time	47 (33.8)
	Part time <21 hour/week	16 (11.5)
	Unemployed	43 (30.9)
	Retired, student, homemaker	26 (18.7)
	Other	7 (5)

Findings

GHHI Healthy Homes Demonstration Project respondents are either the parents or legal guardians of the asthmatic child. The study population consisted of 201 asthmatic children who enrolled and completed the project. Among the study population, 139 (69%) respondents completed the baseline and six month follow-up health survey. As a result, the findings in this section reflect the self-report of 139 respondents living in Baltimore City who completed a baseline assessment, received an intervention, and completed a six month follow-up interview. The survey questions cover the six-month period before the initial home visit and the six months after the intervention.

Participants were referred to the project through medical providers and community-based partners who identified children with asthma complications related to environmental factors in Baltimore city housing. Initial information was collected from the families for baseline data through interviews conducted over the phone. The baseline interviews were followed up with education at the home and comprehensive assessment, which serves to develop a scope of work for the multicomponent intervention. After the intervention was received, a six month follow-up survey interview was performed to determine any changes in the child's asthma since baseline assessment.

The baseline and six month follow-up observation results are presented in Tables 2–4. For each key outcome, Table 5 presents the mean at intake, at six months,, the mean change with standard deviation and one-sided test of the null hypothesis that the mean change is greater than 0. In Table 5, percent reduction equals mean change divided by the mean at baseline.

Table 2. Impact on Asthmatic Child's Symptoms

In past 6 months, how many times has your child's asthma …	*Intake* N *(%)*	*6 Month* N *(%)*	*Percent change*
Asthma symptoms make it harder for child to breathe	140	139	
Never	16 (11%)	31 (22%)	94%
1 time	6 (4%)	12 (9%)	101%
2 time	28 (20%)	27 (19%)	−1%
3 time	18 (13%)	26 (19%)	44%
4 time	15 (11%)	15 (11%)	0%
More than 5 times	57 (41%)	28 (20%)	−51%
Asthma symptoms, wheezing, coughing, shortness of breath wake child up at night	139	138	
Never	24 (17%)	47 (34%)	96%
1 time	4 (3%)	12 (9%)	200%
2 time	21 (15%)	26 (19%)	24%
3 time	21 (15%)	17 (12%)	−19%
4 time	17 (12%)	9 (6%)	−47%
More than 5 times	52 (38%)	27 (20%)	−48%
Asthma control rated by caregiver	143	139	
Well	45 (31%)	69 (50%)	
Somewhat	71 (50%)	63 (45%)	14%
Poorly	17 (12%)	2 (1.5%)	
Out of control	10 (7%)	5 (3.5%)	−74%
Do not know	1 (0.7%)	0	

Table 3. Healthcare Utilization and Productivity Impacts

In past 6 months	*Intake* N *(%)*	*6 Month* N *(%)*	*Percent change*
Calls to Doctors	139	138	
0	31 (22%)	56 (40%)	82%
1 time	29 (21%)	21 (15%)	−28%
2 time	21 (15%)	26 (19%)	24%
3 time	25 (18%)	12 (9%)	−52%
4+ times	33 (24%)	23 (17%)	−30%
Visit to Doctors	139	137	
0	38 (27%)	57 (42%)	50%
1 time	27 (19%)	28 (20%)	4%
2 time	31 (23%)	20 (14%)	−35%
3 time	16 (12%)	16 (12%)	0%
4+ times	27 (19%)	16 (12%)	−41%
Visit to emergency room	140	139	
0	72 (51%)	89 (64%)	24%
1 time	31 (22%)	22 (16%)	−29%
2 time	19 (14%)	15 (11%)	−21%
3 time	9 (6.5%)	9 (6%)	0%
4+ times	9 (6.5%)	4 (3%)	−56%
Hospitalizations	140	139	
0	115 (82%)	127 (92%)	10.4%
1 time	12 (9%)	7 (5%)	−42%
2 time	4 (3%)	2 (1%)	−50%
3 time	5 (3%)	3 (2%)	−40%
4+ times	4 (3%)	0	−100%

Socio-demographics characteristics of demonstration participants

The socio-demographic characteristics of survey respondents are highlighted in Table 1. Nearly half of respondents were fairly young adults between the ages of 18 and 35; yet one-third of the respondents were over the age of 46. Moreover, the vast majority of the respondents were African American (93%), female (94%), and had attained at least a high school diploma (80%). Roughly 45% were employed, the remaining participants were either unemployed (31%), or had a different employment status such as retired, student, or homemaker (19%). Most of the respondents indicated that they were female head of household (70%), and the majority received assistance from social support agencies, including over 75% receiving food stamps.

The survey findings showed project services demonstrated positive results in significantly reducing reported asthma symptoms, use of hospital and emergency room services, and productivity losses at school and work.

Table 4. Impact of Asthma on Quality of Life: School and Work Productivity

In past 6 months	*Intake* N *(%)*	*6 Month* N *(%)*	*Percent change*
Prevented head of household from working	140	139	
Never	34 (24%)	63 (46%)	85%
1 time	5 (3%)	7 (5%)	40%
2 time	22 (16%)	23 (16%)	5%
3 time	20 (14%)	17 (12%)	−15%
4 time	15 (11%)	8 (6%)	−47%
More than 5 times	43 (31%)	20 (14%)	−53%
NA	1 (1%)	1 (1%)	0
Prevented child from attending school or daycare	129	132	
Never	42 (30%)	68 (49%)	62%
1 time	4 (3%)	10 (7%)	150%
2 time	25 (18%)	7 (5%)	−72%
3 time	15 (11%)	6 (4%)	−60%
4 time	8 (6%)	15 (11%)	88%
More than 5 times	35 (25%)	26 (19%)	−26%
NA	10 (7%)	7 (5%)	

Table 5. Mean Difference and Percent Reduction of Key Outcomes

N = *139*	*Intake mean (SD)*	*6 month mean (SD)*	*Pre/post mean change (SD)*	*One-sided t test*	*Percent reduction*
Hospitalizations	0.364288 (0.923013)	0.141791 (0.53667)	0.238806 (0.824248)	0.0008	65.5%
ER visits	0.942857 (1.22193)	0.701493 (1.097022)	0.261194 (1.250137)	0.015	27.7%
Physician visits	1.76258 (1.462491)	1.340909 (1.413293)	0.389313 (1.460098)	0.002	22%
Calls to physicians	2 (1.498792)	1.481203 (1.490381)	0.515152 (1.565296)	0.0002	26%
Work missed	2.76259 (1.954492)	1.736842 (1.85413)	1.037879 (2.057959)	0.0000	37%
School/daycare missed	2.372093 (2.008069)	1.787402 (2.091669)	0.647059 (1.998254)	0.0002	27%

ER, Emergency room; SD, standard deviation.

Symptoms and asthma control

Table 2 presents findings that suggest education combined with multi-component interventions were effective at reducing asthma symptoms and improving asthma control. Asthma control as rated by caregiver was grouped as either controlled (well and somewhat) or not controlled (poorly and out of control). Improvements in child asthma were reported at the six month follow-up with 95% reporting child's asthma as controlled, which is a 74% reduction in those reporting not controlled. The respondents also reported fewer instances of breathing difficulties and waking at night caused by asthma symptoms at the six-month interview. In addition, respondents also indicated a significant 48% reduction in reporting that shortness of breath woke the child more than five times a night.

Asthma-related healthcare utilization

Families often use healthcare services such as calls to physicians, office visits, and pediatric emergency services to respond to their child's lack of asthma control. Table 3 shows there was an overall reduction of healthcare use post-intervention. At baseline 49% of the children had a visit to emergency room and 18% had a hospitalization. Table 5 presents the results from calculating the mean change in pre- and post- observations and percent reduction. The result shows overall utilization of healthcare services had significant reductions in mean differences. Most importantly, project participants reported reductions in the number of hospitalizations (65.5%) and emergency room visits (27.7%).

Impact of asthma on work/school life

Table 4 shows at baseline, many respondents indicated that their child's asthma led to work and school life interruptions. 76% of the respondents reported missing work at least once in the past six months, while 70% of the respondents indicated their child had missed at least one day of school because of asthma complications. Subsequently, at six months post-intervention, the asthmatic child and their caregivers experienced fewer interruptions in work or school life. Table 4 shows significant increase of children never missing school due to asthma (asthma-related perfect school attendance), and 85% of caregivers never missing a day of work were achieved; while Table 5 shows an overall mean reduction of 37% for missed work days and 27% for school or day care missed.

CONCLUSIONS

The GHHI designs model programs, such as the GHHI Healthy Homes Demonstration Project, to address fractured systems, poor coordination, and cost inefficiencies that fail to address home-based environmental health hazards that exacerbate asthma and exist outside the current health system's continuum of care. Upstream investments in low-income housing have the potential for generating sustainable returns on investment and cost savings related to improved health, productivity gains, and wealth retention due to energy conservation. Improved health leads to a reduction in preventable emergency service use and direct cost savings. In 2009 in Baltimore City, the total costs tied directly to asthma were $6 million for hospitalizations (average cost $7,506) and $4.5 million for ED visits (average costs $820) for children; while in Maryland the total costs for children and adults was $26 million for ED visits and $74 million in hospitalization.[24] Direct medical costs of $100 million per year in Maryland are substantial and provide a concrete measure of how asthma morbidity affects society as well as the opportunities for improved health outcomes and corresponding cost reductions. Nationally, the annual direct health care cost of asthma is approximately $50.1 billion; indirect costs (e.g., lost productivity) add another $5.9 billion, for a total of $56.0 billion dollars.[25]

The federal government estimates that energy efficiency retrofits to existing homes could lower energy use by up to 40% per unit, cutting annual greenhouse gas emissions by as much as 160 million metric tons by 2020.[26] Low-income households (less than 200% of

[24]Maryland Asthma Control Program, ''Maryland Asthma Control Plan: An Action Agenda to Reduce the Burden of Asthma in Maryland 2010–2015,'' (Maryland Department of Health and Mental Hygiene).

[25]S. B. Barnett and T. A. Nurmagambetov, ''Costs of Asthma in the Unites States: 2002–2007,'' *Journal of Allergy and Clinical Immunology* 127 (2011):145–52.

[26]Harvard Joint Center for Housing. *The State of the Nation's Housing 2012*. (Harvard, 2012).

federal poverty limit) occupy 35% of the nation's housing stock and account for 31% of residential energy consumption, which is an untapped market potential for energy savings of $13 billion.[27] A large segment of the residential housing market remains underdeveloped in terms of energy efficiency upgrades and represents a significant opportunity to revitalize communities. Finally, the integration of energy conservation with preventive measures of healthy home interventions provides a cost-effective means to stabilize affordable quality housing in low-income neighborhoods.

Healthy housing combined with energy conservation is an environmental justice issue for low-income households. Preservation of affordable quality homes is an effective means of supporting low-income families but requires the development of collaborative public and private partnerships at the local level to coordinate resources.

AUTHOR DISCLOSURE STATEMENT

The authors have no conflicts of interest or financial ties to disclose.

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