Evaluation of Cost Implications of an Asthma Healthy Homes Intervention Program

by

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Dedication

This dissertation is dedicated to my children; first and foremost my daughter Karima Abdi Mohamed Kusow, who began and finished this journey with me, and was generous throughout the years in sharing her Mom with this and other life projects. I cannot thank her enough.

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Abstract

Objective: Environmental conditions can exacerbate asthmatic children's symptoms. The benefit was examined for Healthy Homes University II, an in-home asthma public health program for low-income families which included an assessment for asthma triggers; products and services to reduce exposures; and asthma education.

Design: Case-Control Study; symptomatic asthmatic participants aged <18 in Lansing, Michigan. Program staff assessed homes for asthma triggers and subsequently provided products and services to reduce exposures to cockroaches, dust mites, mold, tobacco smoke, and other triggers. Asthma education included identification of asthma triggers and instructions on specific behaviors to reduce exposures. Controls selected from two similar communities.

Intervention: 250 households received a baseline intervention home visit for health education and product installation, and 3 and 6 month post-intervention home visits. A subset of households received custom interventions.

Participants in study: Children < 18 years of age; income < 80% of Area Median Income; continuously enrolled in Medicaid for a 25 month period and had either one ED visit or one hospitalization due to asthma during the first 12 months of that 25 month period; 40 cases met the inclusion criteria.

Outcome measures: Asthma-related: controller and reliever prescriptions filled, controller and reliever prescription costs, outpatient visits, outpatient costs, emergency department visits, emergency department costs, inpatient stays, inpatient stay costs, overall costs, and intervention costs.

Results: There was a significant increase (p=.04) in the overall utilization of asthma-related controller prescriptions, by an average of 1.2 prescriptions over a 12 month period. There was a significant decrease (p=.006) in the utilization of inpatient stays, by an average of 0.31 stays over a 12 month period. There was no statistically significant

difference in the cost of controller or reliever prescription, emergency department, inpatient stays, outpatient visits, or overall medical costs; the intervention group spent \$4 more on medical care than the control group. With outliers removed, a decrease in inpatient costs by \$694 was significant ($p=.04$), and the difference in total medical costs increased to \$620 and approached statistical significance ($p=.052$). Intervention costs were \$1,882 per household, there was no net-benefit to the intervention, as measured by a savings in medical costs.

Chapter 1

Statement of the Problem

1.1. Significance of the Study

Childhood Asthma is a major public health issue that is costing billions to treat every year. An estimated $19.7 billion was spent on asthma in direct and indirect costs in 2007 in the United States. Almost 24% ($4.7 billion) of this amount was spent on preventable hospital visits [1].

Allergic diseases, including asthma, are the most frequently reported chronic diseases in children, affecting more than 6.2 million children under the age of 18 annually in the United States [1]. Moreover, asthma prevalence, hospitalizations, and deaths have increased steadily among children over the past three decades [2]. The current asthma prevalence rate was 47% higher in blacks than in whites in 2011. Moreover, the highest prevalence rates for whites and blacks were in the 5-17 age group in 2011 [3]. Asthma is also disproportionately associated with poverty, with poor children having a prevalence 1.4 times greater than non-poor children; positive health outcomes and savings can be expected to disproportionately accrue to children at the highest risk of severe asthma [4].

According to one study, the annual per capita employer expenditures for patients with asthma are approximately 2.5 times those of people without the disease [5]. Among children, the mean health care expenditure for those with asthma is roughly 1.5 times higher compared to those without asthma [6]. Black children have higher rates of hospitalization and emergency department (ED) visits than whites, creating a disproportionate economic burden of asthma for these populations [7, 8].

National best practice guidelines for managing asthma, National Asthma Education Prevention Program (NAEPP) guidelines[9] outline four best practices of effective asthma management. These include:

i. Use of objective measures of lung function to assess disease severity and control;
ii. Comprehensive pharmacologic therapy to reverse and prevent airway inflammation and constriction, and to manage exacerbations;
iii. Patient education and
iv. Environmental control measures to avoid or eliminate factors that contribute to asthma onset and severity.

Historically, treatment of asthma has focused on the clinical setting through monitoring of lung function and medication use (best practices 1 and 2). Given the poor control of asthma in population based surveys [10], research is focusing on the implementation of cost-effective education and environmental trigger reduction programs and services (best practices 3 and 4).

The Asthma Network of West Michigan (ANWM) has provided home-based case management services to Priority Health's Medicaid pediatric population on a fee-for-service basis, and also has contracts with four other health plans. However, the current reimbursement agreements do not cover the full costs of the programs, and do not include best practice 4, the implementation of environmental control measures. The cost-effectiveness of these measures have yet to be demonstrated in Michigan. If they can be demonstrated, the expected contribution is lower health care costs and improved health outcomes for children with asthma in Michigan.

Few patients have access to best practices 3 and 4, patient education and control of environmental triggers. It is known that environmental conditions within the home can exacerbate asthmatic children's symptoms. As a result, in-home environmental public health intervention programs that address multiple environmental triggers combined with face-to-face education over multiple home visits have become current program practice. However, many of these initiatives have been grant funded and time-limited, and financial sustainability for such programs remains a challenge.

Little is known about the full costs and benefits of Health Homes Intervention programs to control chronic diseases such as asthma in Michigan.

1.2. Gaps in knowledge

A CDC Task Force has reviewed 13 studies that evaluated costs and the effectiveness of home-based, multi-trigger and multi-component environmental interventions. The Task Force Review and selected studies will be discussed in detail in Chapter 2. Briefly, the Task Force found that gaps in knowledge remain about how particular components impact the overall effectiveness of a multi-faceted intervention [11].

This analysis will use data from a program that had been funded by the US Department of Housing and Urban Development (HUD) in two phases: HHU I (2005 -2008) and HHU II (2008-2011). HHU I program findings showed significant decreases in the impact that asthma had on children and *self-reported*, unscheduled acute health care utilization [2]. This evaluation of HHU II, will use *actual* Medicaid data to measure asthma-related health care utilization. Additionally, the evaluation will compare the intervention group to a control group.

1.3. Research Questions

The purpose of the project is to determine if a return on investment (ROI) can be demonstrated upon analysis of the second round of a program implemented in Lansing, Michigan to study the relationship between the Healthy Homes University (HHU) interventions and utilization of emergency department, hospitalization, urgent care, physician/clinic utilization, and use of controller and rescue medications due to acute asthma events. The project will consider the health benefits and cost-effectiveness of asthma programs that supplement quality clinical care with asthma education and environmental interventions in the home.

1.4. Background on Asthma

1.4.1. Definition and Essential Characteristics

According to the World Health Organization, asthma is characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person, due to inflammation of the air passages in the lungs, so that the nerve endings become easily irritated [12]. In an attack, the lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs [12]. Recurrent asthma symptoms frequently cause sleeplessness, daytime fatigue, reduced activity levels and school and work absenteeism. Asthma has a relatively low fatality rate compared to other chronic diseases.

1.4.2. Course of development

Exposure to allergens and irritants can trigger or exacerbate episodes of asthma, especially in the home [13]. Common asthma triggers in the home environment include dust mites, pets, cockroaches, mice and rats, mold, environmental tobacco smoke, and indoor pollutants. Strategies have been developed to target each trigger respectively [13].

Dust mites are a long established trigger for dust mite sensitive patients, increasing asthma symptoms, pulmonary function, and need for medication. This trigger can be removed through the use of allergen-impermeable pillow and mattress covers, using bedding cleaned in hot water >130 F, removal and disposal of old carpet, reduction in home humidity to <60%, and the washing of stuffed animals weekly [13, 14].

Pet allergens, in particular dog and cat, are a second important trigger; removal of pets from the home is the most effective method to reduce this allergen.

Cockroaches are particularly common in the urban environment, and be hard to eliminate. Allergens can be reduced by using “integrated pest management” strategies to include removing food and water sources, maintaining clean surfaces and floors, sealing trash containers, carefully storing foods, using gel baits for extermination, and sealing all cracks and small holes in the residence.

Mice and rats are also common in inner-city homes, particularly in kitchens. Integrated pest management techniques including filling holes, vacuuming, cleaning, using low-toxicity pesticides, placing traps, and storing food carefully are highly effective [13].

Mold and exposure to dampness accounts for 21% of the asthma in the U.S. [15]. Remediation involves removing mold from hard, non-porous surfaces; discarding mold-contaminated materials (carpet, ceiling tiles); and addressing the sources responsible for mold growth.

Environmental tobacco smoke is linked to increased risk of developing asthma, increased severity, and increased frequency of exacerbations in children with asthma [13]. Interventions are targeted to smokers with asthma, or smokers who are parents of children with asthma, through smoking cessation programs and air filtration methods to reduce the indoor concentration of environmental tobacco smoke [16].

Indoor pollutants include nitrogen dioxide, particulate matter from biomass combustion products, and bacterial endotoxins [17-19]. They are often a trigger for asthma exacerbations, most often through the use of gas stoves, wood-burning appliances or fireplaces [13, 20].

1.4.3. Prevalence and Incidence

1.4.3.1. Major risk factors

Allergies, a family history of allergy, and perinatal exposure to tobacco smoke have been implicated as risk factors for developing asthma [21]. Factors that can exacerbate existing asthma (i.e. can cause or trigger an asthma attack) are much better understood and have been described in section 1.3.1.2. Exacerbations can result from exposure to viral upper respiratory infections, pollen, molds, pet dander, cockroaches, dust mites, tobacco smoke, wood smoke, household chemicals, workplace exposures and some types of air pollution [21]. Also exercise, aggravating conditions that are not properly treated(e.g. rhinitis, gastro esophageal reflux), and stress can also trigger or exacerbate existing asthma [21]. The particular triggers that will exacerbate asthma vary by the individual. If not treated appropriately, asthma can cause long-term loss of lung function and severe outcomes, such as hospitalizations and even death.

1.4.4. Impact on health and health care

1.4.4.1. Mortality, disability, morbidity, and quality of life

Michigan has conducted the Asthma Call-back Survey since 2005, which collects detailed information about asthma symptoms, management, and trigger exposures. It is the only source of Michigan specific asthma information [22]. The data reflected here are Michigan specific and represent response years 2008-2010.

Asthma Symptoms – Children: According to this survey, 16.8% of children with current asthma had asthma symptoms on 9 or more days during the past month.

Difficulty Sleeping Due to Asthma Symptoms – Children: 20.4% of children with current asthma had difficulty sleeping due to asthma symptoms on 2 or more days during the past month. The prevalence was 52.2% higher among children ages 0-9 than children ages 10-17.

Asthma symptom-free days – Children: 57.9% of children with current asthma experienced 14 asthma symptom-free days during the past 2 weeks.11.2% of children with current asthma had asthma symptoms every day of the last 2 weeks.

Usual activities limited due to asthma – Children: 55.4% of children with current asthma experienced limited usual activities due to asthma during the past 12 months. There were no significant differences within age, sex, and race groups; nor within household income or respondent education groups.

Number of school days missed due to asthma - Children: 16.5% of children with current asthma missed 6 or more school days due to asthma in the past 12 months due to asthma. 54.5% of children with current asthma missed no school days due to asthma in the past 12 months due to asthma.

Asthma Emergency Department/ Urgent Care Visits – Children: 9.2% of children with current asthma visited the emergency department or urgent care center for asthma 2 or more times during the past 12 months.

Asthma Hospitalizations – Children: 4.2% of children with current asthma had at least 1 hospitalization for asthma the past 12 months. There were no significant differences within age, sex, or race groups; nor within household income or respondent education groups.

Asthma Action Plans – Children: 45.7% of children with current asthma had received an asthma action plan at some point in their life.

1.4.4.2. Cost, quality, and access

The Asthma Call-back Survey also provides information regarding access to care, quality of care, and some cost barriers to care. The following data [21] are Michigan specific and represent response years 2008-2010:

Asthma Action Plans – Children: 45.7% of children with current asthma had received an asthma action plan at some point in their life.

Asthma Management Class – Children: 12.7% of children with current asthma or an adult in their household have taken an asthma management class at some point in their life.

Advised to Modify Environment to Improve Asthma – Children: 44.6% of respondents for children with current asthma or an adult in their household have been advised by a health professional to modify the child's environment to improve their asthma at some point in their life. The prevalence of having been advised to modify their environment to improve asthma for children with current asthma within household was significantly higher among respondents who attended some college or graduated from college than respondents with less formal education.

Long Term Control Medication Use – Children: 49.1% of children with current asthma had used a long term control medication during the past 3 months. The prevalence of using a long term control medication was significantly higher among respondents who attended some college or graduated from college than respondents who did not attend at least some college.

Routine Asthma care Visits – Children: 45.4% of children with current asthma had 2 or more routine asthma care visits during the past 12 months.

Influenza Vaccine – Children: 51.6% of children with current asthma had an influenza vaccine during the past 12 months. The prevalence of having received an influenza vaccination during the past 12 months for children with current asthma was significantly greater (46.7%) among respondents who Graduated from College than respondents who attended Some College.

Cost Barriers To Care for Children: 10.7% of respondents for children with current asthma reported experiencing a cost barrier to their asthma care during the past 12 months. The most frequent type of cost barrier was related to medication; during the past 12 months, 8.5% respondents for children with current asthma reported needing asthma medication for the child but could not buy it because of cost.

1.5. Applied Significance

If cost-effectiveness of the implementation of NAEPP best practices 3 and 4 can be demonstrated, a business case of investing in asthma education and in-home environmental interventions could be made to health care payers. Gaps in insurance reimbursement and policy implications for payer organizations will be explored. If health insurers routinely reimbursed for these services and supplies, they could become standard components of comprehensive asthma management.

Chapter 2

Review of Literature

2.1. Major analytical approaches

An analysis of the cost-benefit of a Healthy Homes intervention, while straightforward in and of itself is impacted by various factors which affect the eventual adoption of policy changes which would shift expenditures from payers of asthma care from a treatment model to a preventative (healthy homes) approach. The reduction of childhood asthma morbidity and utilization of health care services is complex, and is impacted by selected factors in underlying analytical models. The review of the selected literature is organized according to the concept of healthy homes, cost analysis and cost-benefit research, policy issues, and insurance/managed care.

Over sixty-two articles were identified which were relevant to various aspects of this study. These included articles addressing childhood asthma and healthy homes interventions in particular; defining asthma cases; the unsustainability of high asthma costs; federal support for healthy homes initiatives; prior studies that have evaluated costs and the effectiveness of home-based, multi-trigger and multi-component environmental interventions. The link between housing and health was explored as well as the substantial housing related disparities which remain, and the ability to focus resources on the subpopulations at greatest risk. The use of cost-effectiveness research for U.S public health policy was reviewed, as well as various methods for cost-effectiveness analysis. Articles were also reviewed which focused on the health economics of asthma, and funding models which could potentially pay for healthy homes interventions upstream, especially as it relates to health plans.

2.2. Concept of Healthy Homes

2.2.1. Background

Florence Nightingale, the founder of modern nursing, stated “The connection between the health and the dwelling of the population is one of the most important that exists” [23]. A key characteristic of asthma is the role of environmental exposures in the initiation of the disease and its development. Therefore, the reduction in environmental triggers can determine the difference between its effective management and it being out of control [24]. Although the environmental factors present with asthma are found in all types of homes, sub-standard home environments, disproportionately occupied by low-income and minority populations, allow it to flourish.

The NAEPP guidelines for the diagnosis and management of asthma [14] recognize the importance of reducing exposure to indoor environmental asthma triggers. Furthermore, the reduction of indoor exposures has been shown to improve clinical outcomes [25, 26]. In 2009, a federal Healthy Homes Work Group (HHWG), comprised of representatives from HUD, DHHS,CDC,EPA, Department of Energy, USDA, and other agencies was formed with the goal of ensuring universal access to safe, affordable, and healthy homes [27].

2.2.2. Definition

In 2009 the Surgeon General established a call to action to promote healthy homes; homes which are sited, designed, built, maintained, and renovated in ways that support the health of its residents [23]. The term homes can be single-family homes, apartments, townhomes, duplexes, condominiums, or manufactured homes, and also includes the land immediately around the home and any other structures on the property. The call focused on the impact of housing on public health and urged a coordinated effort to improve housing factors that affect health [27].

Five broad categories are recognized as contributing to adverse health effects in a home [28]: 1) *Physical conditions*, such as heat, cold, energy efficiency, radon exposure, noise, inadequate light, ventilation, and fine particulates in the home. 2) *Chemical conditions* such as carbon monoxide, volatile organic chemicals, secondhand smoke, and lead. 3) *Biological conditions* such as rodents, house dust mites, cockroaches and their associated allergens, and humidity and mold. 4) *Building and equipment conditions*, such as accidents and unintentional injuries and access to sewer services. 5) *Social conditions*, such as architectural features related to mental health.

Healthy Homes interventions generally consist of two parts: an environmental assessment, which uses an assessment survey tool to identify potential indoor contaminants; and environmental trigger education and mitigation, which includes education on trigger education, and the implementation of mitigation techniques [29].

Environmental mitigation techniques can be implemented at three levels [13]:

Major, which includes major structural improvements to the home, such as carpet removal, replacement of ventilation systems, or extensive repairs to restore structural integrity (e.g.to roof, walls, floors).

Moderate, which includes the provision of multiple low cost materials with the active involvement of a trained home visitor: providing a fitting mattress and pillows with allergen-impermeable covers, installation of small air filters and dehumidifiers, integrated pest management, professional cleaning services or equipment, and minor repairs of structural integrity.

Minor, which includes the provision of advice on recommended environmental changes and may include the provision of low-cost items such as mattress and pillow allergen-impermeable covers.

2.2.3. Health Disparities in Access to Healthy Homes

The American Housing Survey (AHS) provides prevalence information on the US housing quality, at the national and city levels. Significant disparities by race and income over time exist with regards to residence in substandard housing. In 2005, AHS data reported that 7.5% of non-Hispanic Blacks, and 2.8% of non-Hispanic Whites, resided in moderately substandard housing [30]. A study from Seattle/King County reported that among children with persistent asthma in households with incomes less than 200% of the poverty line, damp conditions were evident in 65% of the homes, and mold was visible in 38% of the homes [31]. The experience with childhood lead poisoning has shown that effective interventions can reduce such disparities [30]. Between 1976 and 2002, the percentage of children's blood lead levels more than 10 micrograms per deciliter fell from 97% to 3.1% among African American children, by focusing resources on the subpopulations at greatest risk.

2.2.4. Strengths and weaknesses of the approach

The EPA notes that health plans pay a substantial portion of the costs spent annually to treat asthma, and is encouraging insurers to incorporate environmental remediation management into their disease management programs [29]. Of the four best practice components in the NAEPP guidelines, access to best practices 3 and 4, asthma education and environmental interventions, remain scarce, despite increasing evidence that these practices improve symptoms [11, 24].

2.3. Cost Analysis and Cost-Benefit Research

2.3.1. Background

Cost-benefit analysis (CBA) has been put forth as the gold standard of economic evaluation methods [32]. This analysis converts health outcomes into dollar equivalents and compares the costs and consequences (positive and negative) of various intervention strategies in monetary terms [33], by subtracting costs from the value of benefits to estimate the net benefit of an intervention [34]. This method has been widely used in regulatory analyses of environmental health and safety programs, especially by OMB for major regulations expected to have economic impacts greater than U.S. $100 million[34]. It is important to note that the least resource-interventions may be the most cost-effective, but not the most effective [35]. Also, determining which type of intervention is most effective for which type of patient is important. For individuals living in environments with multiple or persistently high levels of asthma triggers, or those with low literacy levels, interventions to reduce environments exposures can be beneficial [24].

2.3.2. Definition

The summary measure of a CBA can be expressed as a net benefit (costs minus benefits), or as a ratio of costs to benefits [33].

2.3.3. Important considerations

A very important consideration in any cost-benefit analysis is *perspective.* The perspective taken by any CBA analysis will determine the final ratio of cost effect. The costs associated with adverse health as well as the costs and benefits of any intervention addressing a health issue are not distributed equally among various groups in society [33]. For example, the perspective of a federal payer (Medicaid for example) may be very different than that of a state payer, a managed care organization, an employer, or a beneficiary. Finally, the overall societal perspective is again different, and impacts public policy decisions, as prevention strategies that are cost-effective to society may not have a positive short-term financial return for payers [34]. The panel on Cost-effectiveness in Health and Medicine recommends the societal perspective, which is often used in public health [36]. In this approach, all significant costs and health effects associated with everyone affected by the intervention are included in the analysis regardless of who pays or benefits [32, 33, 36]. The meaning of the term 'cost-effective" also varies depending on the perspective; for purchasers of health care it may mean in relation to the relative value of different health care services; for producers of health care technologies and programs, it is used to support their marketing claims; finally for advocates of particular illness, it is used to garner resource investments [36].

The pharmaceutical industry and managed care organizations have their own perspectives as well, all of which may differ from what might be most cost-effective for society at large.

This analysis will be from the perspective of an insurer/payer. Of interest are the costs they will incur in producing or arranging for medical care for their subscribers and beneficiaries [36]. As such, the cost categories of interest are the cost of the healthy homes intervention, and the changes in medical benefits, such as the direct medical costs (office visits, hospitalizations, emergency department visit, diagnostic tests, medical supplies, prescription drugs) [33]. Other considerations which will be addressed are the study time frame and the analytic horizon. It is important to note that not relevant to the payer is how rapidly a beneficiary can return to work, as they are not responsible for the disability payments.

2.4. Cost-benefit research related to Asthma and Healthy Homes

There have been a limited number of studies that have compared the economic burden of housing-related adverse health outcomes with the resources required to implement relevant interventions [33]. Asthma related direct and indirect costs attributable to residential exposure in children and adolescents 16 years or younger is estimated at more than $1.1 billion annually [37]. Up to 20% of all asthma cases may be attributable to dampness and mold, at an annual cost of $4.0 billion [15].

A CDC Task Force has reviewed 13 studies that evaluated costs and the effectiveness of home-based, multi-trigger and multi-component environmental interventions [38]. Seven of the studies only provided program costs, and were not able to report direct medical costs averted, or benefit-cost-ratios. Six studies with minor to moderate remediation demonstrated that these interventions provide good value for money invested based on substantial returns for money invested and a cost per symptom free day that is below the standard cut-off for what is considered cost-effective in the literature. Cost-effectiveness studies show a cost of $12 to $57 per additional symptom free day [3 randomized control trials; Krieger (2005), Kattan (2005), and Sullivan (2002)]. The majority of studies in the economic review were interventions for children with asthma, and studies that included adults also included children.

Cost-benefit studies show a return of $5.3 to $14.0 for each dollar invested [3 studies; Oatman (2007), Jowers (2000), and Shelledy (2005)]. These studies all had a pre-post study design, used a 12 month follow-up period, and two of them provided information on direct medical costs averted. The third, Jowers, included productivity costs averted. Regression to the mean may have played a role in these studies, because participants had moderate to severe asthma at the beginning of the study. The previously mentioned randomized controlled trials were more likely to have benefits which were more certainly due to the intervention. Those studies could not show a positive cost-benefit ratio.

2.5. Policy Implications

2.5.1. Background

Recognizing that good health is not merely the result of good medical care, but the result of creating conditions in which people can be healthy, it follows that public policy can be one of the most effective approaches to protecting and improving the health of the population [39]. The Institute of Medicine (IOM) convened a panel of experts to examine the legal and regulatory authority for public health activities, to describe the implications for the changing social and policy context for public health laws and regulations. They identified some of the legal and policy interventions available to improve the public's health. These included the power to regulate; the power to tax and spend; and the power to modify the built environment. They also encouraged the government and private sector to consider *health in all places* (HIAP) approaches, which can act on the social and environmental factors that influence health but are out of the control of the health sector [39].

2.5.2. Economic analyses and policy

Economic analyses can be used to make informed decisions about how to allocate limited resources in a manner that optimizes value for money [40]. Current decision rules have been inadequate to guide choices that would yield the most benefit for the population [40]. There are numerous health related interventions available, with significant development of health care and pharmaceutical technologies used to treat disease, with concurrent rapid growth in costs. Professional and economic incentives continue to expand those services, with the share of the U.S. gross domestic product devoted to health care growing from 5 to 15% between 1965 and 1995 [36]; and currently at 17.9% [12]. Ninety-nine percent of those health care expenditures target individual medical care, leaving few resources to target public health and prevention programs that could benefit the entire population [36]. Attention has focused on acute concerns rather than on the most efficient methods of promoting health through preventative measures. High-tech and profit-generating disease-control strategies are favored over high-touch strategies such as home visiting and home remediation, which cannot be patented and do not capture the interest of the pro-profit health care industry [41]. Certain services are more profitable than others and the relationship between profitability of treatments and their outcomes is a topic avoided by administrators [42].

Asthma is no exception. The annual cost for a year's supply of inhaled fluticasone propionate (220ug) is approximately $2200 per year, compared to costs ranging from $200 to $1500 for home visiting programs [41]. Yet home visit programs are limited, largely because health care payers do not reimburse for them.

2.5.3. Asthma policy

Clinical practice guidelines describing quality health care for asthma have been in existence for two decades. The National Asthma Education and Prevention Program (NAEPP) Guidelines for the Diagnosis and Management of Asthma provide an evidence-based treatment regime [14]. They describe four components of good asthma management including 1) objective assessment and monitoring, 2) pharmacologic therapy, 3) patient education, and 4) environmental control. There exists a gap between what is known to be best practice and what is covered by insurers, required by purchasers, and implemented by providers. The American Lung Association published a National Asthma Public Policy Agenda in 2009 [43]. They provide a comprehensive overview of health-care systems and financing which could impact asthma policy. One of the strategies included was to "*Provide case management, including home-based environmental assessment and remediation, for high-risk patients and those whose asthma is not under good control.*"

The NHLBI Guidelines Implementation Panel Report [44] recommends the development of protocols and coverage for in-home environmental trigger reduction supplies and services for children and adolescent as appropriate and needed. Children and youth whose asthma is not under control should have comprehensive coverage which covers environmental trigger education, environmental interventions such as mattress/pillow covers, HEPA air filters, HEPA vacuums, and integrated pest management. In some cases, remediation may be appropriate as well [11, 24].

2.6. Employers/Managed Care/Health Insurers

2.6.1. Background

Employers expend 2.5 times the amount for patients with asthma compared to patients without the disease [5]. Furthermore, in the U.S. 2007, almost a quarter ($4.7 billion) of the $19.7 billion spent on asthma was spent on preventable visits to the hospital; another 31% of the expenditures ($6.2 billion) was spent on prescription medications [45]. Yet, employers and health insures alike have yet to align employee health benefits with the recommended best practices for asthma management [24]. The effect of such changes can impact employers and health insurers differently. Self-insured employers which offered expanded benefits for asthma care should incur cost-savings, including savings from increased productivity among employees, and incur reduced insurance premiums. Employers who purchase health insurance will not realize any direct cost-savings, but their insurer will from the reduced use of urgent care. However, such employers will benefit from increased productivity and reduced employee absenteeism and increased presenteeism [24]. Such employers can make an evidence based case that premiums should not be increased to cover asthma management, as the service will be cost-effective and may generate cost-savings [24].

Many employers are actually self-insured, and would actually receive the benefits themselves. Further, even when employers are purchasing insurance, a competitive insurance market would yield lower premiums in the long-run when cost-beneficial programs are adopted.

2.6.2. Insurance Reimbursement

There are a number of policy issues related to the implementation of the NAEPP guidelines. From an insurance perspective, major issues remain with insufficient and inconsistent insurance benefits, the high costs of prescription medications, the lack of reimbursement for educational services and case management, and an unwillingness to consider the reduction in environmental exposures. These concerns contrast a CDC review which found that the combination of minor to moderate environmental remediation with an educational component provides good value for the money invested based on improvement in symptom free days, savings from medical costs averted, and improvement in productivity [11].

Some disease management programs are offering some of the asthma best practice components, but very few offer home visits for environmental assessments and interventions. This component may be very important for people whose asthma is not under control [24]. Also, health care employers and purchasers do not want to make changes to their benefits package which may result in increased costs.

The fact that managed care organizations have not been keen on providing primarily behavioral interventions for disease prevention and health promotion services is a longstanding issue [35]. For asthma home visiting and remediation services, initial intervention costs are upfront, and in the case of reduced expenditures for asthma, the benefits and cost-savings may accrue over months or years. Given the expected benefits of reduced urgent care use, reduced absenteeism, and presenteeism, health insurance premiums should not increase as a result of investing in managing asthma [24].

2.6.3. Actions that can impact Health Coverage and Care Practices

Industry Report Cards can play a significant role on health plans emphasis on providing a particular service. The Health Plan Employer Data and Information Set (HEDIS) “is a tool used by more than 90 percent of America's health plans to measure performance on important dimensions of care and service. Altogether, HEDIS consists of 75 measures across 8 domains of care. Because so many plans collect HEDIS data, and because the measures are so specifically defined, HEDIS makes it possible to compare the performance of health plans on an "apples-to-apples" basis [4, 46]. Payers routinely provide incentives to insurers who meet certain benchmarks, known as “Pay for Performance” programs [4]. If a performance measure is established for a particular condition, and it is established as a benchmark, insurers will clamor to increase their outcomes in those areas [47]. HEDIS has adult and child core measures, which are used by the Centers for Medicare and Medicaid. Several of those measures pertain to asthma care.

HEDIS 2013 included the following selected measures on asthma management: enrollees had to have experienced continuous enrollment (for the measurement year and year prior), and the measures were provided for all enrollees ages 5-64, and by age brackets, including children aged 5-11 and 12-18.

Use of Appropriate Medications for People With Asthma (ASM) The percentage of members 5–64 years of age during the measurement year who were identified as having persistent asthma and who were appropriately prescribed medication during the measurement year.

Medication Management for People With Asthma (MMA) Two rates, (1) the percentage of members who remained on an asthma controller medication for at least 50% of their treatment period; (2) the percentage of members who remained on an asthma controller medication for at least 75% of their treatment period.

The State of Michigan Medical Services Administration auto-assigns about 20% of enrollees to insurance plans which are high-performing. An algorithm determines the number of assignees per plan based on how they do on quality metrics. If a health plan wants to focus on a metric, from a business perspective the best reward would be to focus on the metric which determines the auto-assignment of beneficiaries [48]. The metrics used change every year, on a quarterly basis. A managed care provider can be downgraded for a lack of effective prevention services, which may result in declining enrollments [35].

Consolidation of health care may have a positive impact on the provision of preventative services. A health care plan that dominates a particular marketplace, or which owns multiple plans in a particular catchment area, will have an incentive to provide preventative services, as they are more likely to hold on to their enrollees for significant periods of time [35].

Provision or non-provision of services also impacts enrollment in health plans. If there is demand for a particular service, and the health plan does not cover it, they may lose members to a plan that does. Therefore it may be worth the expense to provide the service, regardless of the cost-effectiveness of the intervention [35].

Enrollee and provider demand for services is another determinant in health coverage. Beneficiaries and providers alike demand high cost crisis management interventions that are not necessarily cost-effective. However, there is not the same clamor for preventative measures with benefits in the long-term.

Government mandates are a final determinant of coverage. Governing entities, such as State insurance commissioners, have the authority to require coverage of interventions. This would address the problem of an organization bearing the cost of coverage, whilst another organization accrued the benefits.

2.6.3.1. New Strategies to pay for Preventative Services

The historical fee for service health care model embodied by the U.S. healthcare system lacks incentives for providers and insurers to invest in prevention [49]. A chorus of providers, practitioners, and community health planners are investigation new financing approaches to pay for preventative services on a population level scale, starting at the local level. The following outlines some of the predominant ideas which are being proposed and tested.

Health Impact Bonds propose raising capital from private investors to target community prevention initiatives through evidence –based clinical and community care, and leveraging future health care cost savings to pay for prevention today. Savings from such initiatives are returned to investors, and are re-invested, creating an ongoing system of better health and lower costs. Such a bond is being implemented in Fresno, California, by the University of California, Berkeley, and a health impact investing firm, Collective Health, targeting the incidence and severity of asthma by investing in home-based remediation of environmental conditions in homes of 200 local children with moderate to severe asthma [49, 50]. The California Endowment, a private health foundation, is investing $1.1 million in the project [50], and the intervention is estimated to generate a net savings of $4.5 million, and a return of investment of $1.69 for every dollar spent [49]. If successful, investors will be repaid by the insurers through a portion of the savings realized by lowered emergency department visits, hospitalizations, and post intervention treatment costs.

Wellness Trusts are funding pools typically funded by taxing a levy on insurers and hospitals, in order to support the health and wellness interventions to improve targeted populations. Many of the funded initiatives from such trusts carry out prevention initiatives which are community-based, and which address preventable health conditions, increasing healthy behaviors, and reducing health disparities. This funding mechanism disperses the benefit of the intervention to all members of the targeted population, reducing insurer reluctance to pay for a service for an enrollee which they may ‘lose’, as they may as likely ‘gain’ a member who will have benefited from the investment [49].

Community Benefits requirements were enacted under legislation passed in 1994 which required hospitals, as a condition of their tax-exempt status, to provide “community benefits in the public interest” [49]. About 2,900 or 60% of hospitals nationwide are non-profit, and the tax-exemption was valued at $12.6 billion dollars annually [51]. New requirements under the Affordable Care Act (ACA) require tax-exempt hospitals to do community health needs assessments and improvement plans every three years, and adopt implementation plans which address the community’s health needs [49, 51]. Effective in 2012, community building activities, which focus on upstream environmental, social, and economic factors, are eligible to be counted as community benefit expenditures, providing a new resource to fund prevention activities [52]. The IRS has also asked hospitals to track such expenditures, defined as support for “physical improvement and housing, economic development, community support, environmental improvements, leadership development for community members, coalition building, and community health improvement advocacy, and workforce development” [49, 52]. These activities are understood to benefit the population’s health without the provision of medical care.

A recent literature review of cost-effective analyses indicates that environmental interventions are generally more cost-effective than clinical interventions or non-clinical, person-directed interventions [53]. This may encourage purchasers of health care, as well as other payers, to leverage new payment strategies to pay for preventative services.

Chapter 3

Conceptual Model and Study Hypothesis

3.1. Conceptual Model

The purpose of the project is to conduct a return on investment (ROI) or cost-benefit analysis of the second round of a program implemented in Lansing, Michigan to study the relationship between the Healthy Homes University II (HHU II) Program interventions and utilization of emergency department, hospitalization, urgent care, physician/clinic utilization, and prescription use due to acute asthma events. The project will consider the health benefits and cost-effectiveness of asthma programs that supplement quality clinical care with asthma education and environmental interventions in the home.

Best practices have been identified by NHBLI [9]. If cost-effectiveness of the implementation can be demonstrated, a business case of investing in comprehensive asthma management programs which include comprehensive asthma education and in-home environmental interventions could be made to health care payers and purchasers. Gaps in insurance reimbursement and policy implications for payer organizations will be explored. If health insurers routinely reimbursed for these services and supplies, they could become standard components of comprehensive asthma management.

The Program will be evaluated using a quasi-experimental study in which changes in Medicaid claims for asthma among the intervention group are compared to changes among a control group.

3.2. Hypothesis

The hypothesis is that children with moderate to severe asthma who receive asthma education and environmental interventions in the home will have lower total medical costs related to lowered utilization of outpatient, emergency department, hospitalization, and use of rescue medications due to acute asthma events than children in a matched control group which do not receive any interventions.

Exploratory research questions that will be considered include:

1. Are asthma education and environmental interventions in the home associated with lower utilization of asthma-related outpatient services?
2. Are asthma education and environmental interventions in the home associated with lower costs of asthma-related outpatient services?
3. Are asthma education and environmental interventions in the home associated with lower utilization of asthma-related Emergency Department (ED) services?
4. Are asthma education and environmental interventions in the home is associated with lower costs of asthma-related Emergency Department (ED) services?
5. Are asthma education and environmental interventions in the home associated with lower utilization of asthma-related hospitalizations?
6. Are asthma education and environmental interventions in the home associated with lower costs of asthma-related hospitalizations?

7. Are asthma education and environmental interventions in the home associated with lower utilization of asthma-related rescue medications?
8. Are asthma education and environmental interventions in the home associated with lower costs of asthma-related rescue medications?
9. Are asthma education and environmental interventions in the home cost-effective? Do they result in a cost-savings of asthma –related outpatient, emergency department, inpatient, and prescription services, when taking into account the cost of Healthy Homes' interventions?

Chapter 4

The Intervention

4.1. Introduction

The Healthy Homes II project was implemented from December 15, 2008 through June 14, 2012, and was an $875,000 award from HUD to the Michigan Department of Community Health, Health Homes Section. In addition $144,792 in product carry-over from previous awards, and money collected by the Healthy Homes Section from fines and fees collected were spent on the project. Program match funding of $170,916 were comprised of Health Michigan funds ($36,439), Lead-Safe Housing Program funds ($88,246) and other MDCH program contributions ($44,231). An additional $122,412 was leveraged funds provided by local partnering organizations and product suppliers. Therefore, an estimated $1,313,120 was spent on the project.

4.2. Description of the HHU II Project Population

Two hundred and fifty participants were recruited to participate in the study, 240 of them from Greater Lansing, MI, and ten from Flint, MI. For the purposes of the evaluation, only the Greater Lansing participants were included in the evaluation. All 240 participants received a HHU II Baseline Visit, and were provided with the project protocol. The model included a minimum of four site visits for enrolled families that included a joint health education/home assessment site visit, allergen sampling collection and analysis for 50 of the participant homes, Basic and Custom asthma trigger reduction and injury product installation to address identified health and safety risks in the home, and follow up calls and/or visits. The HHU Program Recruitment and Program Flow Diagram (attrition chart) is in Chapter 5, Table 5.1.

4.2.1. Baseline Demographic Characteristics of the HHU II Project Population

Two hundred and forty participants participated in the project. Applications were prioritized based upon a score matrix. This matrix consisted of 14 child specific questions and 11 housing related questions. Points were awarded based on how each question was answered. High scores were matched with units that housed children under six years old, had an asthma diagnosis and/or symptomology, based on the location and condition of the home, and the presence of multiple children living in the unit. Those applications which scored the highest were placed at a higher priority for completion.

At the conclusion of the project, and for the purpose of this cost-benefit analysis, all participants were matched to the Medicaid database to determine which participants were continually enrolled in Medicaid, 12 months prior to the intervention, during the intervention month, and 12 months post intervention, for a total of 25 continuous months of Medicaid enrollment. Forty participants met this criterion and were deemed to be "in the study". The remaining 200 were deemed to "not be in the cost-benefit study." Table 4.1 provides a description and comparison of the two groups. None of the differences between any of the variables described were statistically significant.

The majority of the participants were male (62.5%), and the remainder female (37.5%). Just under half of the participants were under the age of six (45.8%), and 54.2% were between the ages of six and eighteen (54.2%). The majority of participants were white (49.6%), followed by black (30%) and other races (20%). Hispanics represented 13.8% of the study population.

The majority of the caregivers reported having some college, 46.3%, followed by high school graduates, 22.1%, those with less than high school, 16.7%, and college graduates at 15%.

Virtually all of the participants reported having health coverage (98.8%). Of those, almost 14% were covered by a private insurer, and the vast majority, 75.4%, was covered by public insurance, or Medicaid. Ten percent reported other health insurance coverage.

Almost thirty three percent of the individuals lived in pre-1940 housing, with a similar amount in 1960-1977 housing, twenty percent in post 1978 housing, and almost 14% in 1940-1959 housing. The majority of participants lived in rental housing, 61.3%, and almost 38.8% lived in owner occupied housing.

Finally, a majority, 56.3% of participants received basic and custom interventions, while only 43.8% received baseline interventions only.

Table 4.1: Demographics of HHU II Participants, by Medicaid Study participation

		Received HHU 2 Baseline Visit					
		Medicaid Study (n=40)		Not in Study (n=200)		Total (n=240)	
		No.	%	No.	%	No.	%
Gender	Male	27	67.5%	123	61.5%	150	62.5%
	Female	13	32.5%	77	38.5%	90	37.5%
Age at Baseline (years)	< 6	21	52.5%	89	44.5%	110	45.8%
	6-18	19	47.5%	111	55.5%	130	54.2%
Race	White	22	55.0%	97	48.5%	119	49.6%
	Black	9	22.5%	63	31.5%	72	30.0%
	Other	9	22.5%	39	19.5%	48	20.0%
	Unknown	0	0.0%	1	0.5%	1	0.4%
Hispanic	Yes	7	17.5%	26	13.0%	33	13.8%
	No	33	82.5%	174	87.0%	207	86.3%
Age of Housing	Pre 1940	14	35.0%	64	32.0%	78	32.5%
	1940-1959	5	12.5%	28	14.0%	33	13.8%
	1960-1977	16	40.0%	61	30.5%	77	32.1%
	Post 1978	5	12.5%	44	22.0%	49	20.4%
	Unknown	0	0.0%	3	1.5%	3	1.3%
Healthcare coverage	Yes	40	100.0%	197	98.5%	237	98.8%
	No	0	0.0%	3	1.5%	3	1.3%
Rental occupancy	Owner-Occupied	9	22.5%	84	42.0%	93	38.8%
	Rental	31	77.5%	116	58.0%	147	61.3%
Received Custom or Not	Received Custom	22	55.0%	113	56.5%	135	56.3%
	No Custom	18	45.0%	87	43.5%	105	43.8%
Caregiver Education	< HS	5	12.5%	35	17.5%	40	16.7%
	HS Grad	10	25.0%	43	21.5%	53	22.1%
	Some College	20	50.0%	91	45.5%	111	46.3%
	College Grad	5	12.5%	31	15.5%	36	15.0%
Healthcare Source	Private Employer	6	15.0%	27	13.5%	33	13.8%
	Public	32	80.0%	149	74.5%	181	75.4%
	Other	2	5.0%	23	11.5%	25	10.4%
	Missing	0	0.0%	1	0.5%	1	0.4%

4.3. Project costs

Project costs can be divided into 5 categories. Additionally, project costs can be divided into costs which would be required to implement a similar program by a private entity, with reduced components, which will be deemed “MARGINAL”, “DIRECT”, and “FULL” for evaluation purposes, many of which would not be necessary in the private sector. These components are described in detail in section 4.3.

4.3.1. Personnel

Personnel costs were the largest expense. Over the course of the project, $269,908 was spent on the HHU II Program Manager (included in the DIRECT and FULL costs, and $252,925 on the Family Services Coordinator (Included in the MARGINAL, DIRECT, and FULL cost calculations.

An additional $61,131 was spent on an epidemiologist, who performed statistical analysis of project survey tools that were used to document health outcome measurements. The epidemiologist also performed quality control and quality assurance of survey tools and data management. Additionally, $14,196 was expended for a health analyst to analyze participating family Medicaid records in order for HHU to build surveillance systems of the asthmatic populations to track changes in incidence rates, monitor adherence to treatment protocols, and generate cost justification analyses. These latter costs would not be necessary for implementation in the private sector and will be excluded in the “MARGINAL” and “DIRECT” cost calculations.

4.3.2. Travel

Travel expenses included the conference travel for project staff to Washington, D.C. (15 trips), at a cost of $18,919. This travel included HUD Grantee Orientation and other HUD-sponsored conferences that benefit staff professional development and performance of the Healthy Homes University Program. Additionally, $8,922 was spent on the mileage and parking costs to house the project vehicle. Only these costs would be necessary for implementation in the private sector and will be included in the "MARGINAL" analysis.

4.3.3. Supplies and materials

This item includes consumable supplies (general office supplies, partnership meeting supplies, phone charges , healthy homes course manuals, allergy testing supplies), which totaled $19,719 of the supply budget. This budget category included phone service for arranging appointments with participating families and to conduct follow-up calls with families between home visits. The project provided an in-depth manual (275 manuals at $20/each) to participating families with resource materials that could be consulted for all aspects of the HHU Program's Healthy Homes approach.

Additionally, Allergen testing was performed on fifty (50) units, which was 20% of the 250 total units. This included sampling and analysis by Johns Hopkins School of Medicine Reference Laboratory for dust mites (Dermatophagoides farinae), cockroaches (Bla g I and II), and mouse urinary protein (as needed). The total cost of allergen sampling was $8,459. Samples were collected in food preparation and eating areas and key indicator child living and sleeping areas. Each home received sampling at baseline, 6 month and 12 month intervals.

The costs of the general office supplies and allergen testing were not counted in the calculation of MARGINAL and DIRECT costs.

Supplies also included non-consumable materials, which totaled $166,946 of the supplies budget. Non-consumable materials included the items outlined in Table 4.2.

These included the basic and custom costs for the 240 homes in the HHUII Lansing location, and the 10 homes in the HHUII Flint location. They were included in the MARGINAL, DIRECT, and FULL cost calculations.

The *Basic Intervention services (average cost $449/unit)* consisted of installing the following products, based on the identified needs of the individual home and family: 9-volt batteries ($1.28), D batteries ($0.69), bath mat ($11.68), cabinet safety locks ($2.19), cabinet slide locks ($2.52), carbon filter for air purifier ($19.00), CO detector ($15.50), caulk ($1.80), door mat ($6.30), fan ($9.00), fire extinguisher ($16.20), first aid kit ($5.39), flashlights ($3.60/2pk), foam crack sealant ($2.19), food container- large ($5.40), food containers - small ($18.00/30ct), furnace filter ($3.60), gun trigger locks ($0.00 as they were leveraged from a partner program), HEPA room air purifier ($100.00), HEPA vacuum ($129.99), HEPA vacuum bags ($3.48).hypoallergenic mattress covers (twin - $27.92, full - $35.90, queen - $40.15, king - $51.68), hypoallergenic pillow cover ($4.69), mice baits ($3.60/8pk), nightlights ($1.80), outlet covers ($2.40/30ct), poison control magnet ($0.00), pull-cord wind-ups ($1.80/2pk), roach baits ($6.36/12pk), safety gate ($9.00), shower curtain ($2.10), step stool ($4.50), smoke alarm ($5.00), thermometer ($3.60), trash can with lid ($9.90). Included in these prices were a green cleaning kit to reduce in home chemicals. The kit included the following items: bucket ($1.68), disposable gloves ($7.74/100ct), mop handle ($7.17) and mop head refills ($9.68/3pk) or Swiffer handle ($8.08) and refills ($6.72) depending on flooring surfaces in home, shop towels in a box ($7.20), spray bottle ($1.78), SoftSoap ($1.37), Simple Green ($5.04), and Murphy’s Oil Soap ($4.29).

The Custom Intervention Products (average cost $391/unit) were installed based on need and program compliance of the family. Included products that were installed were: window air conditioning units for eligible housing to be located in subject child's bedroom (average cost $100.00); twin mattress, box spring, and frame ($295.00); full mattress, box spring, and frame ($374.00); dehumidifiers for homes with bedrooms at ground or basement levels (average cost $160.00); and dryer vent repair (average cost $30.00).

Table 4.2: Basic and custom intervention products and services

Basic - Asthma Related Products	Basic - Safety Related Products
HEPA vacuum HEPA room filters Trash can with secure cover Food containers with securing lids Smoking cessation kit Green cleaning supplies Pillow and mattress covers IPM traps and baits Foam crack sealant Caulk Shower curtain Low allergen furnace filters Door mats Fan	Outlet safety plugs Carbon monoxide and smoke detectors Cabinet safety locks Skid proof bathtub mats Fire extinguisher Gun trigger locks Mercury-free thermometers Poison Control Stickers and First aid kits Child safety gate Mini blind cord wind-ups Flashlights and nightlights Step stool Radon test kits
Custom Products	**Custom Services**
Beds and pillows Surge protectors Dehumidifiers Window air conditioning unit Dryer vent/extenders Gutter extenders	Carpet removal and floor replacement Integrated pest management services Slope/yard grading Electrical improvements Garbage removal Moisture control (ventilation, gutter installation, plumbing repair, roof repair)

4.3.4. Consultants

A total of 6 individuals were trained to perform product installation and assessments for healthy homes interventions. Two Technical Assistants (TA's) were hired and trained to install the HHU II products given to the families on the Baseline Site Visits. The HHU II Program Manager, Assistant Field Coordinator and two CDC Apprentices were also trained to administer health questionnaires and education, install basic intervention products, in the event a technical assistant could not attend the scheduled site visit. Additionally, lead paint worker and supervisor educational stipend funding ($500) was provided to five (5) low – moderate-income individuals within the target community to install products and services.

A policy and procedure document was created to delineate the responsibilities and duties of the TA's. In summary, the responsibilities included; performing a visual assessment of all interior and exterior components of the structure, yard and outbuildings for asthma triggers and injury hazards; installation of the intervention products; recording the type, number, and location of each product installed on the room-by-room checklist; walking through the home to identify products, show the family how to use and maintain products and educate the family on products installed within the home. The total spent on product installation and assessments for healthy homes interventions was $50,675. This amount was included in MARGINAL, DIRECT, and FULL costs and calculations.

At the baseline site visit the families completed the baseline survey; received education regarding home asthma triggers and injury control based on answers to the questionnaire; and basic health and safety products were installed within the home. The baseline questionnaire contained questions related to the demographics, family history, symptomatology, quality of life, medical visit frequency, medication usage, asthma knowledge and home environment. The visual inspection identified the environmental, health and safety risks in the unit. It also provided the program with information to determine the priority and level of intervention work needed in a unit. The program staff provided hands-on education regarding asthma triggers, home safety and basic home maintenance to every family. Each family received the HHU II Course Manual which included topics, such as; asthma medications, asthma triggers, asthma action plan, nutrition, smoking cessation resources, home safety, HEPA vacuum and room filters, pesticides, green cleaning products, air scents, asbestos, radon, lead-based paint and local resources. Every family received the installation of the basic products and a subset of families received various custom products and services. Both are outlined in Table 4.2. Baseline and custom products were included in the MARGINAL, DIRECT, and FULL cost calculations.

4.3.5. Other Costs

Financial Administrative Services costs totaled $57,000, and were for the administration of financial services by the Michigan Department of Community Health offices of finance and budget for providing services for LOCC's draw down, purchasing of supplies and overseeing contracts and grant administration.

Environmental Review Public Notices funding in 3 local newspapers at a total cost of $1,500 was expended to meet HUD's Environmental Review Procedures. $400 was spent on the Flint site and $1000 to support neighborhood coalitions.

The part time epidemiologist had indirect costs of $4,780.

The Program Manager and Family Services Coordinator were retained via contract with a non-profit local public health institute that offered flexibility and innovation to the project. This contract charged $5.671 in computer costs, and an indirect of $77,624 over the three years of the project. These ‘other’ costs were only counted in the ‘FULL’ costs calculations.

4.3.6. Total Costs

Project implementation costs totaled $1,313,120. Personnel costs were the largest expense representing 47% of the total cost of the project. This was followed by leveraged/match funds at 22%, supplies/materials at 14%, direct costs at 6%, other indirect costs at 5%, consultants at 4%, and travel at 2%, representing the actual implementation costs.

4.4. Cost Considerations

One way to consider real-world implementation costs, is to consider what the “Marginal” components and marginal costs of a basic intervention program would include; what a more comprehensive program including ‘Direct” costs would include; and finally, the costs of the implementation of the “Full” project as was implementations of the “Healthy Homes University” II project. Of course, each participant in HHU II received a different amount of interventions customized based on their needs, so the “fixed” program costs per person are $1250 for the marginal costs, $2922 for the direct costs, and $4003 for the full costs, illustrated in Table 4.3.

Table 4.3: Elements: Marginal, Direct, & Full Project Comparisons

MARGINAL Costs Description	**Marg_Costs**
Basic remediation	*actual*
Custom Remediation	*actual*
Technical Assistants to install Products	$50,675
Family Services Coordinator	$252,925
Basic Transportation	$8,922
TOTAL fixed MARGINAL costs per person	**$1,250**

DIRECT Costs Description	**Direct_Costs**
Basic remediation	*actual*
Custom Remediation	*actual*
Custom Remediation by Partner	*actual*
TOTAL fixed MARGINAL costs per person	**$1,250**
Technical Assistants to install Products ($50,675)	
Family Services Coordinator ($252,925)	
Basic Transportation($8922)	
addt'l Direct Costs average cost per person	**$1,671**
Leveraged	65,293
Match	82,670
Program Manager	269,908
TOTAL fixed DIRECT costs per person	**$2,922**

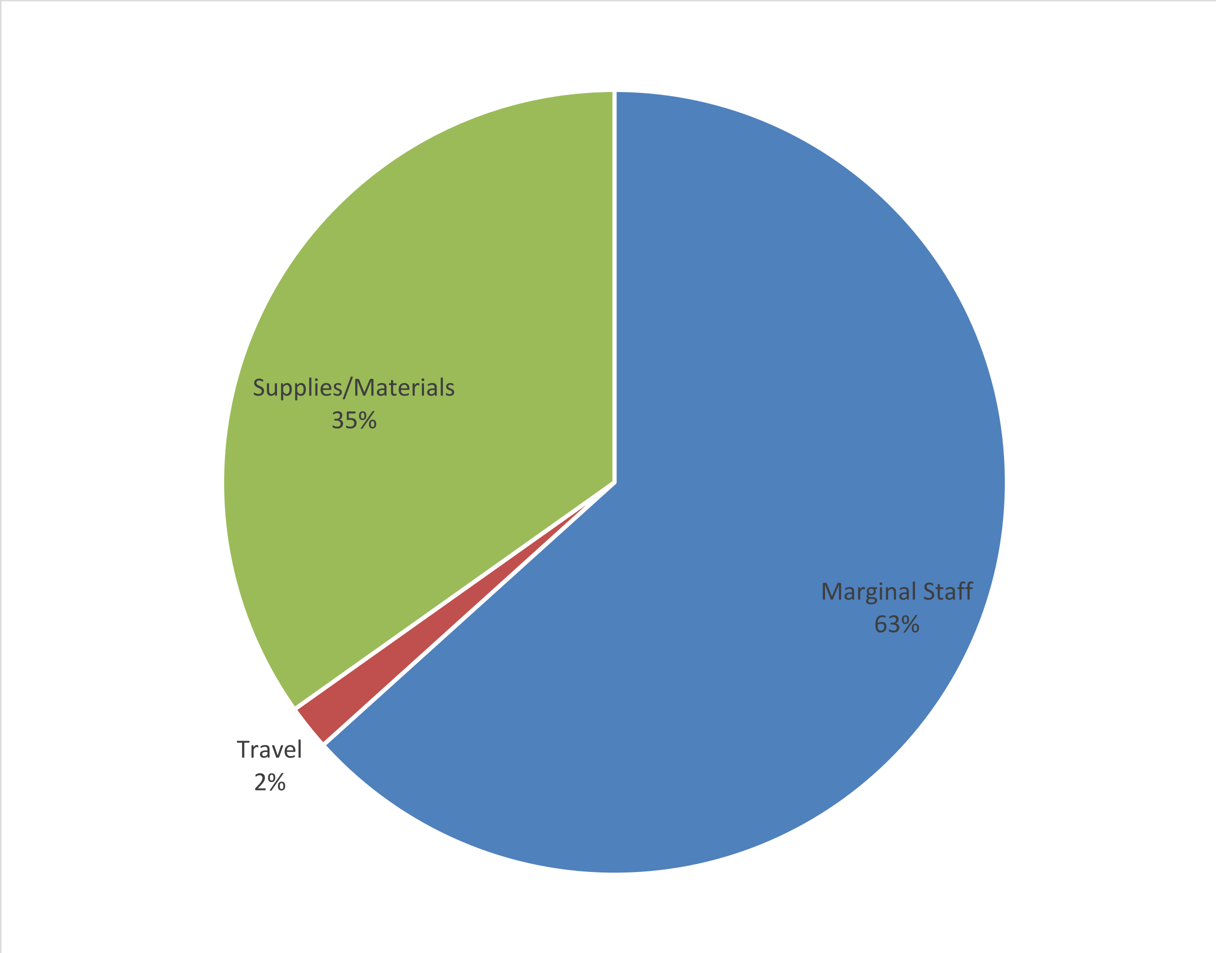
TABLE 4.3 (Cont'd)

Elements: Marginal, Direct, & Full Project Comparisons

FULL Costs Description	Full_Costs
Basic remediation	*actual*
Custom Remediation	*actual*
Custom Remediation by Partner	*actual*
Marginal Staff average cost per person	**$1,250**
Technical Assistants to install Products ($50,675)	
Family Services Coordinator ($252,925)	
Basic Transportation($8922)	
Direct Costs average cost per person	**$1,671**
Leveraged ($65,293)	
Match($82,670)	
Program Manager($269,908)	
addt'l FULL Costs average cost per person	**1,082**
Epidemiologist	$35,959
Epidemiologist Fringe	$25,171
Transportation-HUD	$18,919
Supplies	$19,719
Allergy testing	$8,459
Data Analyst	$14,196
Flint	$400
Neighborhood Coalition	$1,000
Environmental Review Notices	$1,500
RMC -Financial Services MDCH	$57,000
Epidemiologist Indirect	$4,780
MPHI	$77,642
Computers MPHI	$5,671
TOTAL fixed FULL costs per person	**$4,003**

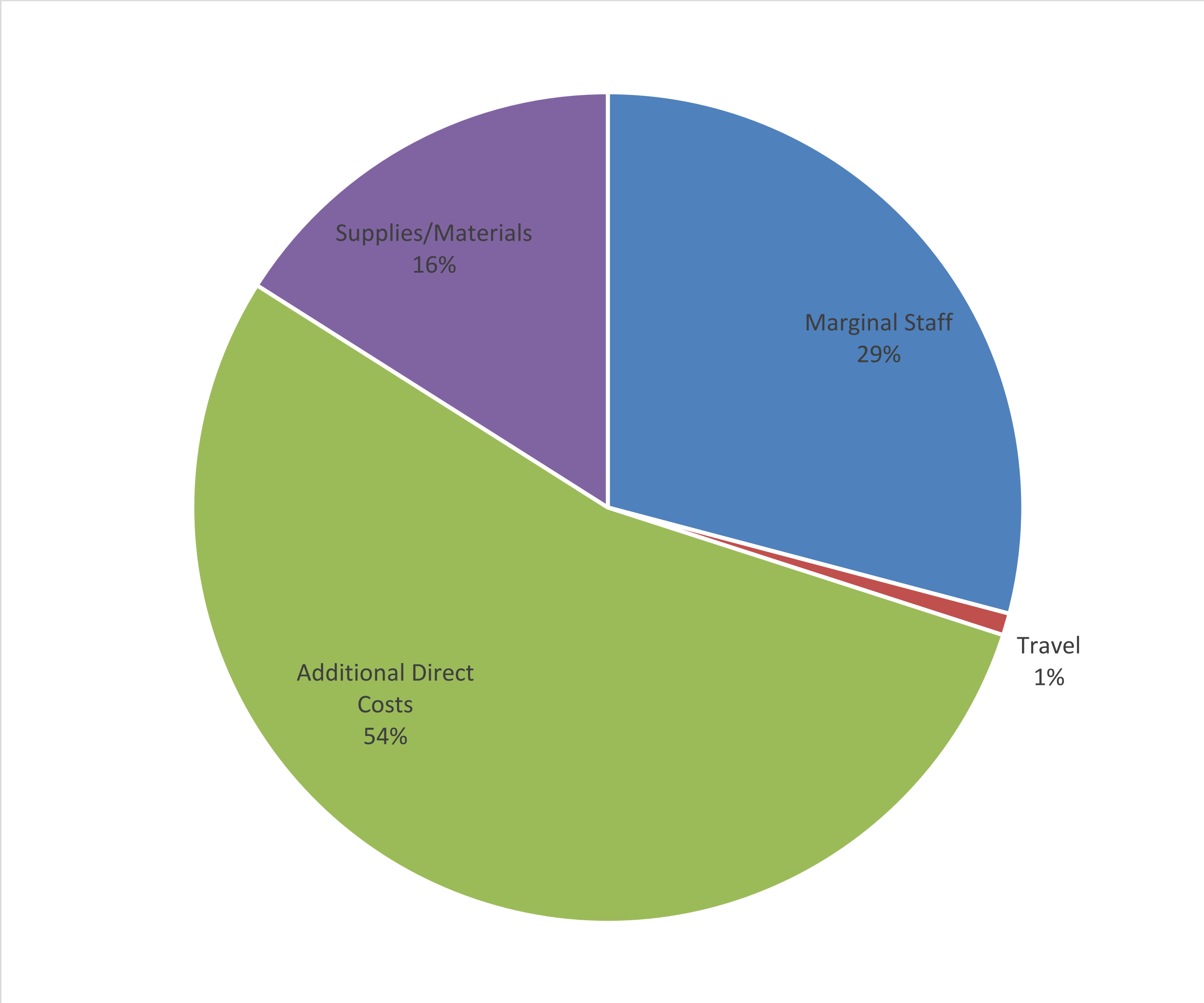
Once the actual remediation costs are added, Figure 4.1, Figure 4.2 and Figure 4.3 show the average marginal ($1,918), direct ($4,171), and full costs ($5,252) per participant in the project.

Figure 4.1: MARGINAL Costs



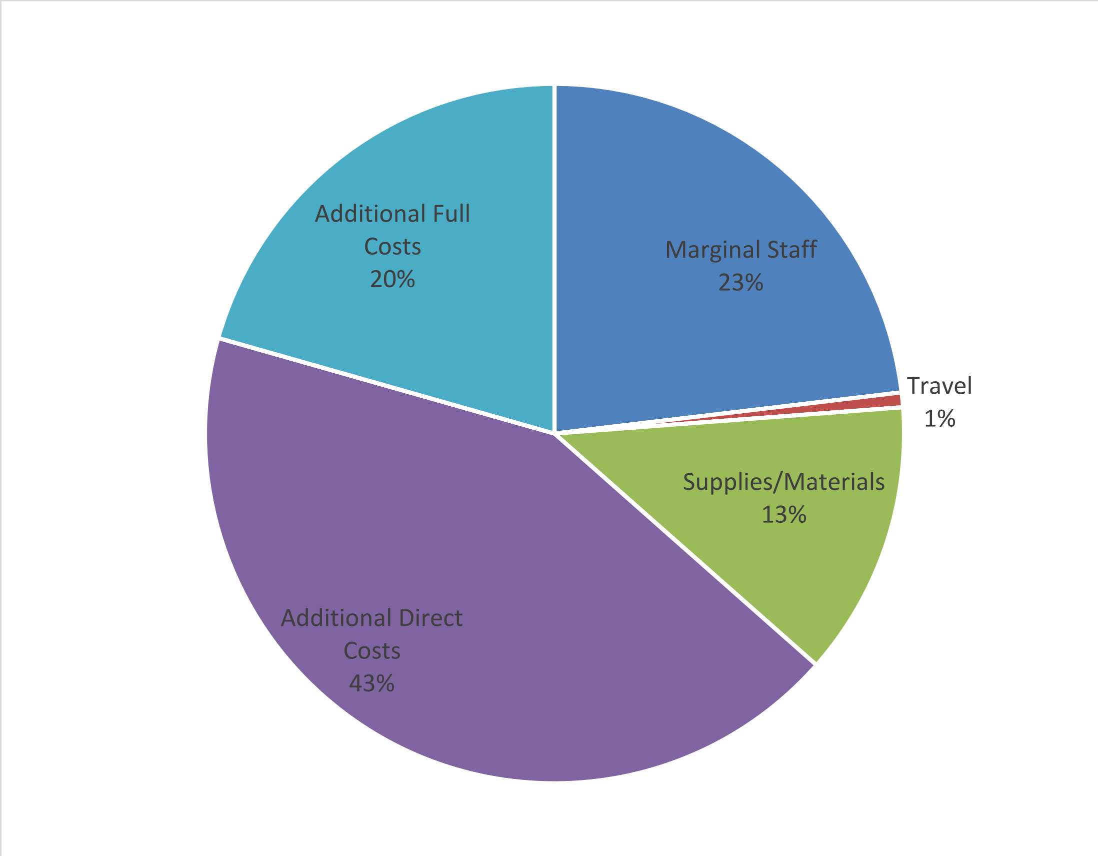
Marginal Staff	**$303,600**	**Supplies/Materials**	**$166,946**
Technical Assistants	$50,675	Basic	$109,635
Family Services Coord	$252,925	Custom	$57,311
Travel	**$8,922**	**Total Cost**	**$479,468**
Basic Transportation	$8,922	**Average cost per participant**	**$1,918**

Figure 4.2: DIRECT Costs



Marginal Staff	**$303,600**	**Additional Direct Costs**	**$563,237**
Technical Assistants	$50,675	Leveraged-custom partner	$56,489
Family Services Coord	$252,925	Leveraged -other	$65,923
		Match-custom partner	$88,246
Travel	**$8,922**	Match-other custom products	$36,439
Basic Transportation	$8,922	Match -other partner	$46,232
		Program Manager	$269,908
Supplies/Materials	**$166,946**		
Basic	$109,635	**Total Cost**	**$1,042,705**
Custom	$57,311	**Average cost per participant**	**$4,171**

Figure 4.3: FULL Costs



Marginal Staff	**$303,600**	**Additional Full Costs**	**$270,416**
Technical Assistants	$50,675	Epidemiologist	$35,959
Family Services Coord	$252,925	Epidemiologist Fringe	$25,171
		Transportation-HUD	$18,919
Travel	**$8,922**	Supplies	$19,719
Basic Transportation	$8,922	Allergen Testing	$8,459
		Data Analyst	$14,196
Supplies/Materials	**$166,946**	Flint	$400
Basic	$109,635	Neighborhood Coalition	$1,000
Custom	$57,311	Environmental Review Notices	$1,500
		RMC -Financial Services MDCH	$57,000
Additional Direct Costs	**$563,237**	Epidemiologist Indirect	$4,780
Leveraged-remediation	$56,489	MPHI	$77,642
Leveraged -other	$65,923	Computers MPHI	$5,671
Match-remediation	$88,246		
Match-other custom products	$36,439		
Match -other partner	$46,232	**Total Cost**	**$1,313,121**
Program Manager	$269,908	**Average cost per participant**	**$5,252**

4.4.1. Comparing Basic and Custom Interventions

To ensure cost-effective methods to address multiple housing related health and safety hazards within the participating units, the installation of Basic Intervention products were based on the results of the visual assessment performed by the Program Manager or Family Services Coordinator. Each unit was provided the Basic and Custom products specifically to control health and safety hazards in the unit. However, for most product installations, work specifications were not required. Technical Assistants installed all products appropriate for each unit. Some Custom Interventions involving repairs and maintenance may have required work specifications. In those instances, the HHU Program adhered to the Michigan Building Code and local building code regulations. For services not addressed in the Code, the Program Manager consulted with the Healthy Homes Section Building Rehabilitation Specialist to develop appropriate specifications. Specifications and contractor bid procedures were modeled after the Lead-Safe Homes program.

4.4.2. Basic and Custom Products and Services Costs for HHU II Project

The mean cost for the basic intervention was $456, with a range between $268 and $723. The mean custom cost was $230, with a range between $252 and $4527. The mean cost for those who received basic and custom products was $687, with a range between $252 and $5108 (Table 4.4).

Table 4.4: Costs of Basic, Custom, and Total (Basic and Custom) Intervention

Products and Services for all HHU II participants (n=240)

	N	Min	Max	Mean	S.D.
Basic	240	$268	$723	$456	$77
Custom	240	$252	$4,527	$230	$479
Basic and Custom	240	$252	$5,108	$687	$510

The mean basic costs were similar for the study and non-study project participants, and were not significantly different (Table 4.5).

Table 4.5: Costs of Basic Intervention Products and Services

Study (n=40) versus Not in Study (n=200)

	N	Min	Max	Mean	Range	S.D.
Not in Study	200	$268	$723	$456	$455	$77
In Study	40	$252	$602	$460	$350	$81

The mean custom costs were similar for the study and non-study project participants, and were not significantly different (Table 4.6).

Table 4.6: Costs of Custom Intervention Products and Services

Study (n=40) versus Not in Study (n=200)

	N	Min	Max	Mean	Range	S.D.
Not in Study	200	$0	$4,527	$242	$4,527	$516
In Study	40	$0	$726	$172	$726	$217

The mean total basic and custom costs was comparable between the two groups, the study group and the not in study group and were not significantly different (Table 4.7).

Table 4.7: Costs of Basic and Custom Intervention Products and Services

Study (n=40) versus Not in Study (n=200)

	N	Min	Max	Mean	Range	S.D.
Not in Study	200	$268	$5,108	$698	$4,840	$547
In Study	40	$252	$1,190	$632	$938	$254

The mean total basic and custom costs, including partner remediation costs, was comparable between the two groups, the study group and the not in study group and were not significantly different (Table 4.8).

Table 4.8: Costs of Basic and Custom Intervention Products and Services including Partner Remediation Costs

Study (n=40) versus Not in Study (n=200)

	N	Min	Max	Mean	Range	S.D.
Not in Study	200	$268	$21,944	$1,269	$21,676	$2,715
In Study	40	$252	$8,539	$829	$8,287	$1,276

4.4.3. Custom Intervention Products and Services

The majority of the custom intervention products were bed related products; mattresses (14.7%), bed frames (12.6%), and box springs (11.6%), for a total of 38.9% of all custom products. These were followed by air conditioning units (12.4%), pillows

(11.9%), and dehumidifiers (11.1%). Combined, these products represented 74.3% of all custom products provided (Table 4.9).

Table 4.9: Custom intervention products and services

	Frequency	Percent	Valid Percent	Cumulative Percent
AC	48	12.4	12.4	12.4
Bath sink plumb	1	0.3	0.3	12.6
Bathroom moisture control	1	0.3	0.3	12.9
Bathtub surrounds	1	0.3	0.3	13.1
Bed Frame	49	12.6	12.6	25.8
Box Spring	45	11.6	11.6	37.4
Carbon Pre Filter	1	0.3	0.3	37.6
Carpet Removal-SC Bed	1	0.3	0.3	37.9
Change Order	1	0.3	0.3	38.1
Dehumidifier	43	11.1	11.1	49.2
Dryer Vent Hookup/Extension	16	4.1	4.1	53.4
Fan install	1	0.3	0.3	53.6
Flooring Replacement	2	0.5	0.5	54.1
Gutter Extenders	19	4.9	4.9	59
Gutter maintenance	1	0.3	0.3	59.3
HEPA Filter and/or Carbon Filter	12	3.1	3.1	62.4
HVAC SVC	1	0.3	0.3	62.6
IPM	3	0.8	0.8	63.4
Kichen Repair Ceiling Repair Carpet Removal	1	0.3	0.3	63.7
landscaping	1	0.3	0.3	63.9
Mattress	57	14.7	14.7	78.6
Mattress Cover	7	1.8	1.8	80.4
Moisture Reduction	2	0.5	0.5	80.9
Outlets	1	0.3	0.3	81.2
Painting	1	0.3	0.3	81.4
Pillows	46	11.9	11.9	93.3
Plumbing	1	0.3	0.3	93.6
Roof Repair	1	0.3	0.3	93.8
Safety rails for bed	1	0.3	0.3	94.1
Sash lock	1	0.3	0.3	94.3
steps/walk replacement	1	0.3	0.3	94.6
Surge Protector	16	4.1	4.1	98.7
Totes	3	0.8	0.8	99.5
Tub wrap	1	0.3	0.3	99.7
Vacuum Maintenance	1	0.3	0.3	100
Total	388	100	100	

Chapter 5

Methodology and Research Design

5.1. Study Design

The study is a case-control study of the cost implications of an Asthma Healthy Homes Intervention Program.

The primary outcomes of interest are medical costs, defined as the total expenditures on healthcare claims during the 12 month period following the intervention. Average costs for this period were assessed for asthma related: outpatient office and clinic visits, other outpatient services, emergency department visits, inpatient stays, and outpatient prescription drug expenditures, and are compared with a 12 month period prior to the intervention. Healthcare utilization was also compared for each of these categories.

Study participants were children less than 18 years of age at the end of the observation period (i.e., 13 months post Baseline visit); Family Income < 80% of Area Median Income; selected among a sampling pool of those continuously enrolled in Medicaid for a 25 month period between March 2008 and January 2012 & had either one ED visit or one hospitalization due to asthma during the first 12 months of that 25 month period.

Data for cases and controls come from Michigan Medicaid claims data and were obtained from the Community Health Automated Medicaid Processing System (CHAMPS). The time period of Medicaid claims data is March 1, 2008 –December 31, 2012. The database contains information on the enrollment, as well as medical (outpatient, inpatient, emergency department care, physician office visits) and pharmacy claims.

CHAMPS was used to identify and characterize individuals eligible to serve as the control study group, and were pulled from comparable populations in Kalamazoo and Jackson, Michigan. Medicaid claims data was matched to program participants and controls and downloaded into a database.

The intervention group comprised of participants in a US Department of Housing and Urban Development (HUD) project, Healthy Homes University (HHU II) which operated from December of 2008 through December of 2011 (36 months) In Ingham, County, MI and some surrounding zip codes.

The monetary program costs which covered the complete period of the HHU II grant period were obtained, as well as the basic intervention costs and custom intervention subtotal costs for each subject in the intervention group, for the period of November 1, 2008 - November 31, 2011.

5.2. Identification of Intervention and Control Populations

Controls were selected from Kalamazoo and Jackson Counties, one from each county for each of the 40 intervention group members. To ensure that the same time periods were included by both intervention and study groups, controls were selected for each of the 25 month timeframes experienced by the intervention group. For example, if an intervention group member had their Baseline Visit in January 2010, then one control from Kalamazoo and one control from Jackson was selected for which the 25 month timeframe was January 2009 – January 2011. As with the intervention group, to qualify as a control, the person had to have had either an ED visit or hospitalization with a primary diagnosis of asthma during the 12 month “Pre” period.

5.2.1. Intervention Population: HHU II Program participants were selected using the following criteria:

Age <18 years of age at the end of the observation period (i.e., 13 months post Baseline visit); Residents of Ingham County, MI and zip codes 48906, 48911, and 48917 of Eaton County and 48906 of Clinton County; Family Income < 80% of Area Median Income. Each intervention group member had a 25 month Medicaid study period. “Base Month/Year” was the month/year in which the intervention occurred. The “Pre” period was the 12 months prior to the “Base Month/Year.” The “Post” period was the 12 months following the “Base Month/Year”. To qualify as being an intervention group member for the purposes of the Medicaid analysis, the person had to be continuously enrolled in Medicaid over this 25 month period and had to have had either an ED visit or a hospitalization with a primary diagnosis of asthma during the 12 month “Pre” period.

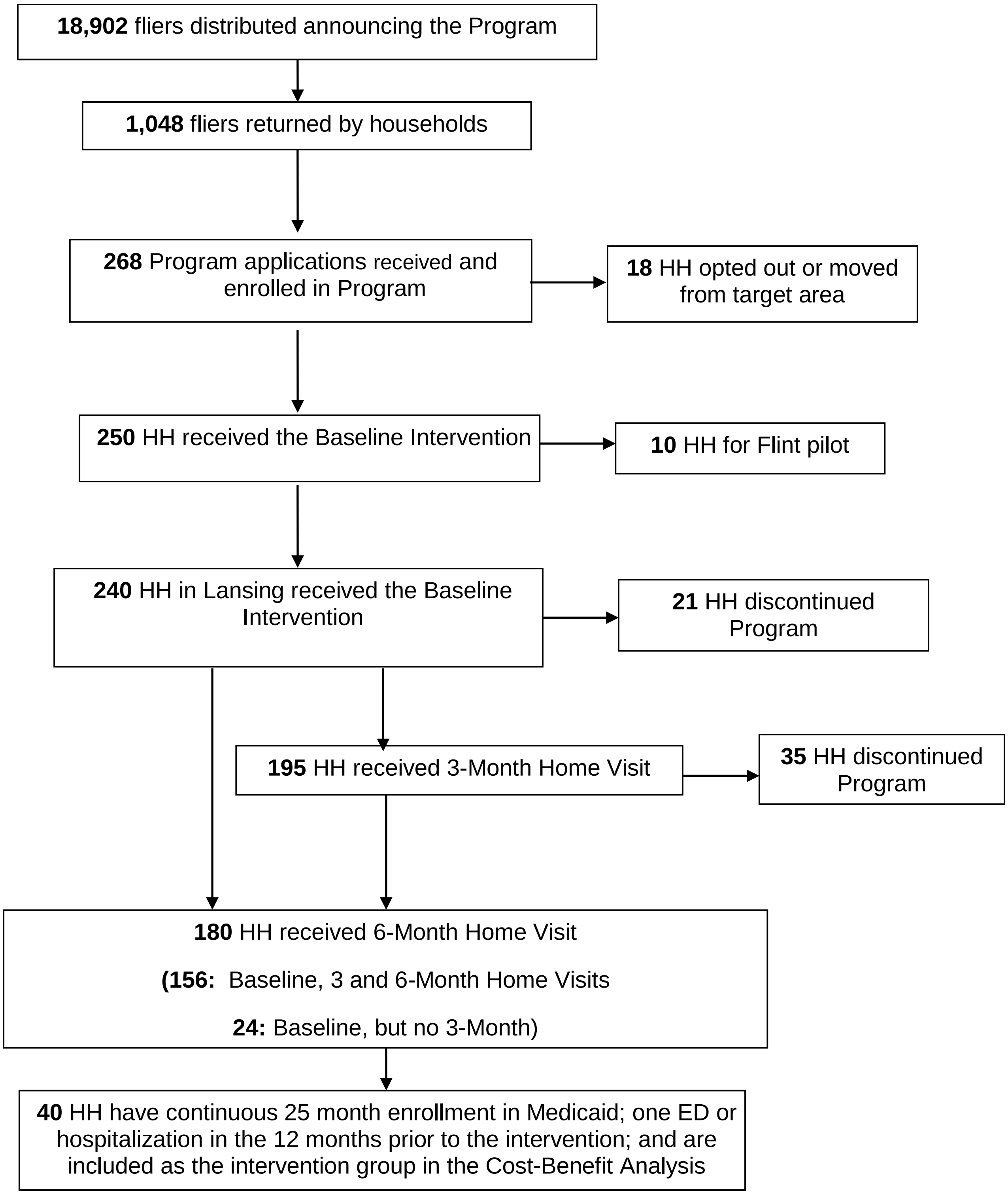
5.2.2. Control Group:

Age <18 years of age at the end of the observation period; selected among a sampling pool of those continuously enrolled in Medicaid for a 25 month period between March 2008 and January 2012. Controls were selected from Kalamazoo and Jackson Counties, which did not have asthma intervention programs such as HHU; one from each county for each of the 40 intervention group members. Because asthma exacerbation is correlated with time of year, controls were frequency matched by the 25 month timeframe of the intervention group (12 months pre-intervention month, the intervention month, 12 months post-intervention month). For example, if an intervention group member had their Baseline Visit in January 2010, then one control from Kalamazoo and one control from Jackson was selected for which the 25 month timeframe was January 2009 – January 2011. As with the intervention group, to qualify as a control, the person had to have had either an ED visit or hospitalization with a primary diagnosis of asthma during the 12 month “Pre” period.

5.3. Participant Flow Diagram and Attrition table

The program recruitment and participant flow diagram for the project is illustrated in Table 5.1. The data entry was completed, ie program application and risk assessment pre/post results were entered into the database. Data quality assurance was completed, as data points and sources of data were re-entered and verified by internal and external peer review.

Table 5.1: HHU II Program Recruitment and Participant Flow Diagram



5.4. Methods for the calculation of each cost type

5.4.1. Variables of Interest

The model for this study contains a number of variables that were collected reflecting different points in time. Variables were collected for the 12 month period prior to the baseline month; at the baseline month; for the 12 month period post the baseline month; and for the intervention group, the 36 month period of the Healthy Homes University II intervention project (Table 5.2).

Table 5.2: Study Variables Collected at Each Study Phase

12 month period prior to Baseline Month (Pre Period)	Baseline month	12 months post Baseline Month (Post Period)	36 month study period *for intervention group only*
Number of outpatient visits*	Age at Baseline	Number of outpatient visits*	Basic Costs
Costs of outpatient visits*	Age Group at Baseline:	Costs of outpatient visits*	Custom Costs
Number emergency department visits*	< 3 years	Number emergency department visits*	Custom Partner Costs
Costs of emergency department visits*	3-5 years	Costs of emergency department visits*	Total Remediation Costs
Number of inpatient stays*	6-12 years	Number of inpatient stays*	Marginal Staff Costs
Costs of inpatient stays*	13-<19 years	Costs of inpatient stays*	Total Marginal Costs
Number prescriptions filled*	Gender	Number prescriptions filled*	Direct Costs
Costs of prescriptions filled*	Race	Costs of prescriptions filled*	Total Direct Costs
			Indirect Costs
			Full Costs
* all services asthma-related			

Key demographic variables were obtained from the Medicaid database, including the child's age at baseline, gender, and race. The child's date of birth was used to compute the child's age at the baseline month, which was a continuous variable. An age group at baseline variable was created which was nominal. The gender and race variables were also nominal variables. To assess the utilization of asthma-related medical services, the total number of asthma-related OP visits, ED visits, IP stays, and prescriptions filled were obtained from the Medicaid claims records of each child for the

12 months prior to the baseline month; and separately, for the 12 months post the baseline month.

5.4.2. Identification of Asthma-related Services by Place of Service

5.4.2.1. Outpatient Costs

Outpatient services were identified if the procedure code was 99201-99205; 99211-99215; or 99241-99245, and were flagged as asthma related if the ICD-9 was in the 493 series (Table 5.3).

Table 5.3: Chronic Obstructive Pulmonary Disease and Allied Conditions

ICD-9 Codes **Asthma 493**
493.0 Extrinsic asthma
493.00 Extrinsic asthma, unspecified
493.01 Extrinsic asthma with status asthmaticus
493.02 Extrinsic asthma with (acute) exacerbation
493.1 Intrinsic asthma
493.10 Intrinsic asthma, unspecified
493.11 Intrinsic asthma with status asthmaticus
493.12 Intrinsic asthma with (acute) exacerbation
493.2 Chronic obstructive asthma
493.20 Chronic obstructive asthma, unspecified
493.21 Chronic obstructive asthma with status asthmaticus
493.22 Chronic obstructive asthma with (acute) exacerbation
493.8 Other forms of asthma
493.81 Exercise induced bronchospasm
493.82 Cough variant asthma convert 493.82 to ICD-10-CM
493.9 Asthma unspecified
493.90 Asthma,unspecified type, unspecified
493.91 Asthma, unspecified type, with status asthmaticus
493.92 Asthma, unspecified type, with (acute) exacerbation

Facility fee screens were obtained from the Michigan MDCH Physician Primary Care Rate Increase Initiative Database, January 2014**.** The non-facility fee for events occurring outside of southeast Michigan was attached to each event and calculated. The events were then assigned to period 1 or period 2, by beneficiary. Finally, the total number of outpatient visits for period 1 and period 2, as well as the total cost for each period was calculated for each case.

5.4.2.2. ED costs

Emergency Department services for each event were identified if the Revenue Flag code was in the 450 series (045X) and if the cases were flagged as asthma related if the ICD-9 was in the 493 series (Table 5.3).

The Department of Health and Human Services, Centers for Medicare & Medicaid Services (CMS), Outpatient Prospective Payment System (OPPS) determines payment amounts for designated hospital outpatient services. The OPPS generally applies to designated hospital outpatient services furnished in all classes of hospitals, although there are a few exceptions which do not apply to this study. In most cases, the unit of payment under the OPPS is the Ambulatory Payment Classifications (APC). CMS assigns individual services (Healthcare Common Procedure Coding System [HCPCS] codes) to APCs based on similar clinical characteristics and similar costs. The payment rate and copayment calculated for an APC apply to each service within the APC. Within each APC, payment for dependent, ancillary, supportive, and adjunctive items and services are packaged into payment for the primary independent service [54].

The final OPPS Ambulatory payment classifications (APCs) for calendar year 2014 were obtained from CMS. Each event's HCPCS procedure code was matched to the corresponding APC code and relative weight, (Addendum B.-Final OPPS Payment by HCPCS Code for CY 2014) to determine the corresponding payment rate for the facility charge. The professional fee charge for each event's HCPCS procedure code was determined from the MDCH Physician Primary Care Rate Increase Initiative Database, January 2014, and added to the facility charge, to determine a cost for each event. The rates used were for Michigan Locality 99 (all counties not included in the Locality 01 area of SE Michigan).The events were then assigned to period 1 or period 2, by for each case. Finally, the total number of emergency department visits for period 1 and period 2, as well as the total cost for each period was calculated for each case.

5.4.2.3. Inpatient Costs

CMS uses a prospective payment system (PPS) model to control costs. This system is a per-case reimbursement mechanism under which inpatient admission cases are divided into relatively homogeneous categories called Medicare Severity Diagnosis Related Groups (MS-DRGs),commonly known as DRGs. Hospitals are typically paid a set fee for treating all patients in a DRG, regardless of the actual cost for that case. One DRG is assigned to each inpatient stay. The DRGs are assigned using the principal diagnosis and additional diagnoses, the principal procedure and additional procedures, sex and discharge status. Diagnoses and procedures assigned by using ICD-9-CM codes determine the MS-DRG assignment.

Each DRG is assigned a weight. The weight is used to adjust for the fact that different types of patients consume different resources and have different costs. Groups of patients who are expected to require above average resources have a higher weight than those who require fewer resources. Weights are updated annually to reflect changes in medical practice patterns, use of hospital resources, diagnostic and procedural definitions and DRG assignment criteria [54].

In this DRG prospective payment system, Medicare pays hospitals a flat rate per case for inpatient hospital care so that efficient hospitals are rewarded for their efficiency and inefficient hospitals have an incentive to become more efficient [54].

DRG codes were obtained for each event. Events which were coded with DRG codes 202-203 (Table 5.4) were determined to be asthma-related. If the DRG code was missing then the ICD-9 code was evaluated, and if it was in the in the 493 series (Table 5.3), it was determined to be an asthma-related event. The relative weight to be used for each DRG was obtained from MDCH, Medicaid Grouper 31.0, for calendar year 2014. The Michigan Medicaid Hospital DRG rates for 2014 were obtained from the Michigan Medicaid website. The average total operating cost and capital cost was calculated for all in state hospitals, which was $4188 (Michigan Medicaid Hospital DRG rates; 2014).This average DRG cost was used as the hospital multiplier to calculate inpatient stay costs for each event according to its specific DRG. The events were then assigned to period 1 or period 2, by beneficiary. Finally, the total number of inpatient stays for period 1 and period 2, as well as the total cost for each period was calculated for each case.

Table 5.4: DRG Codes used to identify Asthma-Related Inpatient Stays

DRG Codes	Description
202	Bronchitis & asthma w CC/MCC
202.1	Bronchitis & asthma w CC/MCC
203	Bronchitis & asthma w/o CC/MCC
203.1	Bronchitis & asthma w/o CC/MCC

5.4.2.4. Rx Costs

Prescription drugs were flagged as asthma related if they were identified as an Asthma Controller and Reliever Medications according to HEDIS (the Healthcare Effectiveness Data and Information Set) (Table 5.5). The drugs were then classified as controller or rescue drugs according to the HEDIS guidelines. The dispensing date, days supply and NDC code were obtained for each prescription claim. A dispensing event was defined using HEDIS guidelines, as one prescription of an amount lasting 30 days or less. If multiple prescriptions for the same medication were dispensed on the same day, the days supply was summed and divided by thirty. Dispensing events were calculated based on HEDIS specifications. The National Average Drug Acquisition Cost (NADAC) for Medicaid Covered Outpatient Drugs was obtained from the Centers for Medicaid and Medicare Services, for the week of November 14, 2014, and was used to calculate prescription costs. Unit costs and pricing units were obtained, and if a generic drug was available, the generic price was used. Costs were calculated for each prescription based on the days supply, cost per unit, and unit packaging. Standard dispensing fees were obtained from Medicaid Services Administration, Bulletin MSA-09-58, and added to the prescription cost.

The month each prescription was filled was assigned to period 1 or period 2, by beneficiary. Finally, the total numbers of asthma-related prescription fills were calculated for period 1 and period 2, as well as the total cost of all the prescriptions for each period, for each beneficiary.

Table 5.5: Asthma Controller and Reliever Medications

Asthma Controller Medications			
Description	Prescriptions		
Antiasthmatic combinations	• Dyphylline-guaifenesin	• Guaifenesin-theophylline	
Antibody inhibitors	• Omalizumab		
Inhaled steroid combinations	• Budesonide-formoterol	• Fluticasone-salmeterol	• Mometasone-formoterol
Inhaled corticosteroids	• Beclomethasone • Budesonide • Ciclesonide	• Flunisolide • Fluticasone CFC free • Mometasone	• Triamcinolone
Leukotriene modifiers	• Montelukast	• Zafirlukast	• Zileuton
Mast cell stabilizers	• Cromolyn		
Methylxanthines	• Aminophylline	• Dyphylline	• Theophylline
Asthma Reliever Medications			
Description	Prescriptions		
Short-acting, inhaled beta-2 agonists	• Albuterol • Levalbuterol	• Metaproterenol • Pirbuterol	

http://www.ncqa.org/HEDISQualityMeasurement/HEDISMeasures/HEDIS2013/HEDIS2013FinalNDCLists.aspx
Table AMR-A

5.5. Statistical Analysis Methods

The data processing and statistical analyses for this study was performed using the Statistical Package for the Social Sciences (SPSS), Version 22 (IBM Software).

5.5.1. *Descriptive Statistics*

Descriptive analyses of the children enrolled in the study were conducted, describing the age distribution (<1-2yrs, 3-5yrs, 6-12 yrs, 13-<19 yrs), gender, and race of enrolled children for the control and intervention group (Chapter 6; Table 6.1).

Two group, pre/post intervention analyses using the Mann-Whitney non-parametric test for independent samples for a significant improvement ($P<.05$) in specific outcomes was used. Unadjusted differences in the average costs of care were calculated between the cohorts, and the frequency of each outcome was described in the population. Outcomes to be tested were asthma-related outpatient visits, asthma-related outpatient costs, asthma-related ED visits, asthma-related ED costs, asthma-related hospitalizations, asthma-related hospitalization costs, asthma-related controller and reliever prescriptions filled, asthma-related controller and reliever prescription costs, and overall asthma-related costs. Means with standard deviation, medians, and interquartile ranges were reported for all the variables.

Utilization

Descriptive statistics of asthma-related medical care utilization were calculated for the variables of interest for the pre-intervention period, comparing the control and intervention groups (Chapter 6; Tables 6.2, 6.3). Correlation coefficients were generated to test for relationships between each independent and dependent variables.

Descriptive statistics of asthma-related medical care utilization were calculated for the variables of interest for the post-intervention period, comparing the control and intervention groups (Chapter 6; Tables 6.4, 6.5). Correlation coefficients were generated to test for relationships between each independent and dependent variables.

The difference in asthma-related utilization for each group between the pre period and the post period were calculated for each group, and descriptive statistics were reported. Correlation coefficients were generated to test for relationships between each independent and dependent variables (Chapter 6; Tables 6.6, 6.7).

Costs

Descriptive statistics of asthma-related medical care costs were calculated for the variables of interest for the pre-intervention period, comparing the control and intervention groups (Chapter 6; Tables 6.8, 6.9). Correlation coefficients were generated to test for relationships between each independent and dependent variables.

Descriptive statistics of asthma-related medical care costs were calculated for the variables of interest for the post-intervention period, comparing the control and intervention groups (Chapter 6; Tables 6.10, 6.11). Correlation coefficients were generated to test for relationships between each independent and dependent variables.

The difference in asthma-related medical care costs for each group between the pre period and the post period were calculated for each group, and descriptive statistics were reported. Correlation coefficients were generated to test for relationships between each independent and dependent variables (Chapter 6; Tables 6.12, 6.13).

5.5.2. General linear regression

General linear regression was used to determine any changes in utilization during the pre and post periods, adjusting for age at baseline, race, and gender. The mean and standard error were reported for the control and intervention group, and a significance test was reported at $p < .05$ (Chapter 6; Tables 6.14 - 6.26).

General linear regression was used to determine any changes in medical care costs during the pre and post periods, adjusting for age at baseline, race, and gender. The mean and standard error were reported for the control and intervention group, and a significance test was reported at $p < .05$ (Chapter 6; Tables 6.27-6.29).

5.5.3. Exclusion of outliers

Because the data was not normally distributed, some analyses were conducted removing the outliers, notably a comparison of means for the change in utilization between the two groups. For each variable of interest, outliers were removed for that specific interest area, and noted in the table (Chapter 6, Table 6.30).

Similarly, a comparison of means for the change in costs between the two groups was also conducted, with the respective outliers removed for each variable of interest in the analysis (Chapter 6, Table 6.31).

5.5.4. General Linear Regression with the Exclusion of Outliers

General linear regression was used to determine any changes in medical care costs during the pre and post periods, adjusting for age at baseline, race, and gender. Each type of medical care (emergency department visits, inpatient stays, prescriptions and outpatient costs) was run separately with its respective outliers removed. The mean and standard error were reported for the control and intervention group, and a significance test was reported at p <.05 (Chapter 6; Tables 6.32-6.35). The model for total medical costs with outliers removed was also run to determine any changes in medical care costs during the pre and post periods, adjusting for race only (Chapter 6, Table 6.36).

5.5.5. Comparisons of Cost Calculations

The unadjusted net benefit of the intervention on total medical costs was compared against: a regression model; an unadjusted net benefit of the intervention on total medical costs with outliers removed; a regression model of the adjusted net benefit of the intervention on total medical costs with outliers removed; and finally, a regression model of the adjusted net benefit of the intervention on total medical costs with outliers removed, and controlling only for race (Chapter 6, Table 6.36).

5.5.6. Models including intervention costs

This section compares the marginal, direct, and full costs of the intervention described in Chapter 4 (see Tables 4.3 – 4.8 and Figures 4.1 – 4.3) against the healthcare savings for each calculation method (unadjusted change in costs, adjusted change in costs, unadjusted change in costs without outliers, and adjusted change in costs without outliers) (see Chapter 6, Table 6.13).

5.5.7. Protection of rights of human subjects

The Michigan Department of Community Health (MDCH) IRB was obtained on 10/15/2013 under the title "Healthy Homes University Evaluation and Cost-Benefit Analysis"; it was approved by expedited review without modifications, MDCH IRB Log # 201310-07-EA.

The Health Sciences and Behavioral Sciences Institutional Review Board serving the University of Michigan Main Campus, reviewed the proposal, “Evaluation of Cost Implications of an Asthma Healthy Homes Intervention Program”, HUM00099348, on 03/02/15 and gave a Notice of Determination of “Not Regulated” Status. It was determined that IRB approval was not required as the data cannot be tracked to a human subject.

Chapter 6

Results

6.1. Subject Characteristics

Of the 240 participants in the Healthy Homes University II project, 40 participants met the inclusion criteria for the study, and were identified as the intervention group (I). Eighty individuals were identified for the control group (C). The control group had a larger percentage of Black children(C=55%, I=38%), whereas the intervention group had a larger percentage of Hispanic participants (C=3%, I=18%). Gender Distribution were similar between the two groups, with over 65 of participants being male in both groups (C=65%, I=68%). Age at baseline were similar for both groups, with over 55% of subjects being 5 years or under (C=59%, I=57%), and over 27% of subjects in both groups being age 2 or under (C=33%, I=27%). None of the demographic characteristics were significantly different between the two groups (Table 6.1).

Table 6.1: Baseline Demographic Information for Healthy Home University II Cost-Benefit Study

	Control		Intervention		p-value
	Number	*%*	*Number*	*%*	
Age at Baseline					0.494
Less than or equal to 2 yrs	26	32.50%	6	26.67%	
3 to 5 years	21	26.25%	15	30.00%	
6 to 12 years	18	22.50%	16	28.33%	
13 to less than 19 years	15	18.75%	3	15.00%	
TOTAL	80	100.00%	40	100.00%	
Race					0.788
Black	44	55.00%	15	37.50%	
White	27	33.75%	17	42.50%	
Hispanic	2	2.50%	7	17.50%	
Other	7	8.75%	1	2.50%	
TOTAL	80	100.00%	40	100.00%	
Gender					0.238
Male	52	65.00%	27	67.50%	
Female	28	35.00%	13	32.50%	
TOTAL	80	100.00%	40	100.00%	

6.2. Utilization of Services

There were two areas of asthma-related medical care utilization which were statistically significant between the two groups during pre-intervention period, prescription use and outpatient visits (Table 6.2 and Table 6.3). It is important to note that cases included in the intervention and control groups were selected based on minimum levels of utilization, not average utilization – i.e. they experienced either an ED visit or an inpatient stay with a primary diagnosis of asthma in the 12 months of the “pre” period.

6.2.1. Pre period

Prescription Use

There is a statistically significant difference in the utilization of both controller and reliever medications between the control and intervention groups in the Pre period, with the intervention group using twice as many controller medications (C=2.45, I=5.70, p=<.001), and one and a half times as many rescue medications (C=2.99, I=4.53, p=<.001) (Table 6.2).

Table 6.2: Unadjusted Utilization of Asthma Controller and Rescue Prescriptions, during the PRE period between HHU II intervention and control groups

	CONTROL				**INTERVENTION**				
	Mean	***Median***	***S.D.***	***IQR***	***Mean***	***Median***	***S.D.***	***IQR***	***P-Value**** *(means)*
RX Controller Scripts Pre	2.45	1.00	3.14	4.00	5.70	4.00	5.29	7.75	**0.00**
RX Rescue Scripts Pre	2.99	2.00	2.88	4.00	4.53	4.00	3.15	4	**0.00**

** significance level is .05; independent samples Mann-Whitney U test*

ED Utilization

There was no statistically significant difference in the mean number (C=1.46, I=1.48, p=.596) and median number (C=1.0, I=1.0, p=.823) of asthma-related emergency department visits between the two groups in the 12 months prior to the intervention month (Table 6.3). Both groups averaged about 1.5 ED visits during the pre-intervention period.

Inpatient Utilization

There was not a statistically significant difference in the mean number (C=0.20, I=0.45, p=.116) and median number (C=0.0, I=0.0, p=.246) of asthma-related inpatient stays between the two groups in the 12 months prior to the intervention month (Table 6.3). On average, both groups did not experience an inpatient stay during the pre-intervention period, although the intervention rate was double that of the control group.

Outpatient Utilization

There was a statistically significant difference in the mean number of asthma-related outpatient visits during the 12 months prior to the intervention month (C=0.95, I=3.05, p<.001) between the two groups, with the intervention group averaging three times as many visits as the control group (Table 6.3). There was also a significant difference in the median number of asthma-related outpatient visits used in the 12 months prior to the intervention month, with the intervention median being twice as much as the control group. (C=1.0, I=2.0, p<.001).

Table 6.3 Unadjusted Utilization of Asthma-Related Emergency Department, Inpatient, Outpatient Services during the PRE period between HHU II intervention and control groups

	CONTROL				INTERVENTION					
	Mean	*Median*	*S.D.*	*IQR*	*Mean*	*Median*	*S.D.*	*IQR*	*P-Value* (medians)*	*P-Value* (means)*
ED Visits	1.46	1.00	1.38	0.00	1.48	1.00	1.47	1	0.823	0.596
IP Stays	0.20	0.00	0.43	0.00	0.45	0.00	0.81	1	0.246	0.116
OP Visits	0.95	1.00	1.23	1.75	3.05	2.00	2.96	3.75	**<.001**	**<.001**

*** significance level is .05; independent samples Median test and Mann-Whitney U test**

6.2.2. Post period

Descriptive statistics of asthma-related medical care utilization were calculated for the variables of interest for the post-intervention period, comparing the control and intervention groups. The same two services, prescription use and outpatient visits, had statistically significant differences in the post-intervention period as well (Table 6.4 and Table 6.5).

Prescription Use

There was a statistically significant difference in the utilization patterns of both controller and rescue medications between the control and intervention groups in the Post period, with the intervention group using two and a half times as many controller medications (C=2.97, I=7.70, p=<.001), and more than one and a half times as many rescue medications (C=3.09, I=5.13, p=<.001) (Table 6.4).

Table 6.4: Unadjusted Utilization of Asthma Controller and Rescue Prescriptions, during the POST period between HHU II intervention and control groups

	CONTROL				INTERVENTION				
	Mean	***Median***	***S.D.***	***IQR***	***Mean***	***Median***	***S.D.***	***IQR***	***P-Value**** *(means)*
RX Controller Scripts Post	2.97	1.00	3.71	5.00	7.70	6.00	6.65	10.75	**0.00**
RX Rescue Scripts Post	3.09	2.00	3.88	3.25	5.13	4.50	3.76	5.75	**0.00**

** significance level is .05; independent samples Mann-Whitney U test*

ED Utilization

There was no significant difference in the mean number (C=0.53, I=0.70, p=.777) and median number (C=0.0, I=0.0, p=.839) of asthma-related emergency department visits between the two groups in the 12 months post the intervention month**.** Both groups averaged less than 1 ED visit during the post-intervention period (Table 6.5).

Inpatient Utilization

There was no significant difference in the mean number (C=0.13, I=0.08, p=.942) and median number (C=0.0, I=0.0, p=.713) of asthma-related inpatient stays between the two groups in the 12 months post the intervention month. On average, both groups did not experience an inpatient stay during the post-intervention period. However the intervention group experienced almost half as many inpatient stays as the control group. This is in contrast to the pre intervention period, when the intervention group had experienced double the number of inpatient stays as compared to the control group (Table 6.5).

Outpatient Utilization

There was a statistically significant difference in the mean number of asthma-related outpatient visits during the 12 months post the intervention month (C=0.96, I=2.33, p<.001) between the two groups, with the intervention group averaging two times as many visits as the control group. This is a reduction from the pre period, when the intervention group experienced three times as many asthma-related outpatient visits as the control group. There was also a significant difference in the median number of asthma-related outpatient visits used in the 12 months post the intervention month, with the intervention median being twice as much as the control group. (C=0.0, I=2.0, p=.005) (Table 6.5).

Table 6.5: Unadjusted Utilization of Asthma-Related Prescriptions Medications, Emergency Department, Inpatient, and Outpatient Services during the POST period between HHU II intervention and control groups

	CONTROL				INTERVENTION					
	Mean	***Median***	***S.D.***	***IQR***	***Mean***	***Median***	***S.D.***	***IQR***	***P-Value**** *(medians)*	***P-Value**** *(means)*
ED Visits	0.53	0.00	0.87	1.00	0.70	0.00	1.20	1	0.893	0.777
IP Stays	0.13	0.00	0.46	0.00	0.08	0.00	0.27	0	0.713	0.942
OP Visits	0.96	0.00	1.41	1.75	2.33	2.00	2.43	4	**0.005**	**<.001**

** significance level is .05; independent samples Median test and Mann-Whitney U test*

6.2.3. Difference in Utilization Pre – Post

The difference in asthma-related utilization for each group between the pre period and the post period were calculated. There was a statistically significant change in utilization of asthma controller medications (Table 6.6), as well as inpatient visits between the two groups (Table 6.7).

Prescription Use

There is a statistically significant difference in the change in utilization of asthma controller and rescue medications between the two groups between the two time periods, with the intervention group increasing its use of controller medications four times as much as the control group (C=-0.53, I=-2.00, p=<.03). The change in the difference of utilization patterns of the rescue medications between the two groups was not statistically significant, although the intervention group increased its use of rescue medications more than the control group(C=-0.10, I=-0.60, p=<.47) (Table 6.6). As the numbers are negative, this indicates an increase in the use of rescue medications for both groups.

Table 6.6: Unadjusted Benefit of Asthma Controller and Rescue Prescriptions between HHU II intervention and control groups

	CONTROL				INTERVENTION					
	Mean	***Median***	***S.D.***	***IQR***	***Mean***	***Median***	***S.D.***	***IQR***	***P-Value**** *(means)*	***Net benefit***
RX Controller Scripts	-0.53	0.00	3.07	3.00	-2.00	-1.00	3.34	3.75	**0.03**	-1.47
RX Rescue Scripts	-0.10	0.00	3.16	2.25	-0.60	0.00	3.66	4.75	0.47	-0.50

** significance level is .05; independent samples Mann-Whitney U test*

ED Utilization

There was no significant difference in the change of the mean number (C=0.94, I=0.78, p=.626) and median number (C=1.0, I=1.0, p=.341) of asthma-related emergency department visits between the two groups, during the two time periods**.** However, both groups averaged a decrease in the number of ED visits during the post-intervention period, with a median difference of 1 in both groups (Table 6.7).

Inpatient Utilization

There was a statistically significant difference in the change of the mean number (C=0.08, I=0.38, p=.024) of asthma-related inpatient stays between the two groups, during the two time periods**.** Both groups experience a decrease in the average number of inpatient stays. However, the intervention group, which had experienced twice as many inpatient stays as related to the control group during the pre-intervention period, experienced half as many inpatient stays during the post intervention period, accounting for this important finding, that the intervention did have a significant effect in decreasing the number of inpatient visits (Table 6.7).

Outpatient Utilization

There was not a statistically significant difference in the change of the mean number (C=-.01, I=0.73, p=.166) of asthma-related outpatient visits between the two groups, during the two time periods**.** The intervention group experienced a decrease in the average number of outpatient visits, while the control group experienced a slight increase. This decrease was more than proportional, even though it did not reach significance (Table 6.7).

Table 6.7: Unadjusted Benefit of Asthma-Related Emergency Department, Inpatient, and Outpatient Use between HHU II intervention and control groups

	CONTROL				INTERVENTION						
	Mean	*Median*	*S.D.*	*IQR*	*Mean*	*Median*	*S.D.*	*IQR*	*P-Value* (medians)*	*P-Value* (means)*	**Net benefit**
ED Visits	0.94	1.00	1.54	1	0.78	1.00	1.64	1	0.341	0.626	-0.16
IP Stays	0.08	0.00	0.47	0	0.38	0.00	0.74	1	0.059	**0.024**	0.30
OP Visits	-0.01	0.00	1.42	2	0.73	0.00	2.84	3	0.201	0.166	0.74

** significance level is .05; independent samples Median test and Mann-Whitney U test*

6.3. Costs of Services

The difference in asthma-related medical care costs between the pre period and the post period were calculated for each group, and descriptive statistics were reported.

Correlation coefficients were generated to test for relationships between each independent and dependent variables (Table 6.9).

It is important to note that costs were calculated as utilization multiplied by actual 2014 prices. Since prices are the same for both groups for both periods, the results for costs should be similar to the results for utilization. However, the mix of the specific types of drugs and visits could be different.

6.3.1. Pre period

Descriptive statistics of asthma-related medical care costs were calculated for the variables of interest for the pre-intervention period, comparing the control and intervention groups (Table 6.9). Correlation coefficients were generated to test for relationships between each independent and dependent variables.

Prescription Costs

There was a statistically significant difference in the mean cost of asthma-related prescriptions used in the 12 months prior to the intervention month, with the intervention group costing twice as much as the control group (C=$453, I=$925, $p<.001$). There was also a difference in the median cost of asthma-related prescriptions used in the 12 months prior to the intervention month, again with the intervention group's median cost being almost twice as much as the controls' cost (C=$233, I=$448, $p<.081$).
When separated into types of asthma-related prescriptions, controller or rescue medications, there is a statistically significant difference in the costs of both of these medications between the two groups in the Pre period, with the intervention group's mean cost of controller medications costing twice as much as the control group

(C=$393, I=$795, p=<.001), and as well as the mean cost of the rescue medications costing twice as much as the control group (C=$72, I=$130, p=<.0001) (Table 6.8).

Table 6.8: Unadjusted Costs of Asthma Controller and Rescue Drugs during the PRE period among HHU II participants and a control group

	CONTROL				INTERVENTION				
	Mean	**Median**	**S.D.**	**IQR**	**Mean**	**Median**	**S.D.**	**IQR**	**P-Value*** *(Mean)*
Pre-RX Controller Costs	$393	$224	662.93	612.78	$795	$649	673.58	901.30	**0.000**
Pre-RX Rescue Costs	$72	$37	105.49	87.61	$130	$95	109.79	176.91	**0.000**

** significance level is .05; independent samples Mann-Whitney U test*

ED Costs

There was no significant difference in the mean cost (C=$385, I=$482, p=.126) and median number (C=$263, I=$390, p=.081) of asthma-related emergency department visits between the two groups in the 12 months prior to the intervention month (Table 6.9)**.** Both groups averaged over $385 during the pre-intervention period.

Inpatient Costs

There was no significant difference in the mean cost (C=$1358, I=$1167, p=.205) and median number (C=0.0, I=0.0, p=.246) of asthma-related inpatient stays between the two groups in the 12 months prior to the intervention month (Table 6.9).

Outpatient Costs

There was a statistically significant difference in the mean cost of asthma-related outpatient visits during the 12 months prior to the intervention month (C=$71, I=$272, p<.001) between the two groups, with the intervention group costing almost four times as much as the control group (Table 6.9). There was also a significant difference in the median cost of asthma-related outpatient visits used in the 12 months prior to the intervention month, with the intervention median coast being four times as much as the control group. (C=$42, I=$175, p<.001).

Total Medical Costs

There was a statistically significant difference in total medical costs during the Pre intervention period between the two groups (C=$2268, I=$2845, p<.001). The intervention group spent $577 more on total medical costs as compared to the control group during the Pre intervention period (Table 6.9).

Table 6.9 Unadjusted Costs of Asthma-related Care during the PRE period among HHU II participants and a control group

	CONTROL				INTERVENTION						
	Mean	**Median**	**S.D.**	**IQR**	**Mean**	**Median**	**S.D.**	**IQR**	**P-Value*** *(Median)*	**P-Value*** *(Mean)*	**Difference**
RX Costs	$453	$233	730.65	666.80	$925	$735	741.42	1027.81	**<.001**	**<.001**	$472
ED Costs	$385	$263	389.98	192.80	$482	$390	448.35	289.48	0.081	0.126	$97
IP Costs	$1,358	$0	5016.42	0.00	$1,167	$0	2287.24	2366.64	0.246	0.205	-$192
OP Costs	$71	$42	100.43	99.51	$272	$175	273.29	295.72	**<.001**	**<.001**	$201
Total Medical Costs	$2,268	$737	5241.53	1133.42	$2,845	$2,137	2664.88	2575.86	**<.001**	**<.001**	$577

** significance level is .05; independent samples Median test and Mann-Whitney U test*

6.3.2. Post period

Descriptive statistics of asthma-related medical care costs were calculated for the variables of interest for the post-intervention period, comparing the control and intervention groups (Tables 6.10 and 6.11).

Prescription Costs

There was a statistically significant difference in the mean cost of asthma-related prescriptions used in the 12 months post the intervention month, with the intervention group costing twice as much (C=$469, I=$1074, p<.001) (Table 6.10). There was also a statistically significant difference in the median cost of asthma-related prescriptions used in the 12 months post the intervention month, with control group median $208 and the intervention group median $863, four times as high (C=$208, I=$863, p<.001).

When separated into types of asthma-related prescriptions, controller or rescue medications, there is a statistically significant difference in the costs of both of these medications between the two groups in the Post period, with the intervention group's mean cost of controller medications costing twice as much as the control group (C=$450, I=$1056, p=<.001), and as well as the mean cost of the rescue medications costing twice as much as the control group (C=$75, I=$158, p=<.001) (Table 6.10).

Table 6.10: Unadjusted Costs of Asthma Controller and Rescue Drugs during the POST period among HHU II participants and a control group

	CONTROL				INTERVENTION				
	Mean	**Median**	**S.D.**	**IQR**	**Mean**	**Median**	**S.D.**	**IQR**	**P-Value*** *(Mean)*
RX Controller Costs	$450	$193	943.68	597.02	$1,056	$838	949.13	1179.66	**0.000**
RX Rescue Costs	$75	$41	119.08	103.03	$158	$137	129.84	184.73	**0.000**

** significance level is .05; independent samples Mann-Whitney U test*

ED Costs

There was no significant difference in the mean cost (C=$149, I=236, p=.126) and median number (C=0, I=0.0, p=.081) of asthma-related emergency department visits between the two groups in the 12 months post the intervention month (Table 6.11).

Inpatient Costs

There was no significant difference in the mean cost (C=$334, I=$203, p=.205) of asthma-related inpatient stays between the two groups in the 12 months post the intervention month (Table 6.11).

Outpatient Costs

There was a statistically significant difference in the mean cost of asthma-related outpatient visits during the 12 months post the intervention month (C=$74, I=$246, p<.001) between the two groups, with the intervention group costs averaging three times as much as the control group. There was also a significant difference in the median difference in costs between both groups(C=0.0, I=$142, p=.005) (Table 6.11).

Total Medical Costs

There was a statistically significant difference in total medical costs during the Post intervention period between the two groups (C=$1026, I=$1759, p<.001). The intervention group spent $733 more on total medical costs as compared to the control group during the Post intervention period (Table 6.11).

Table 6.11: Unadjusted Costs of Asthma-related Care during the POST period among HHU II participants and a control

	CONTROL				INTERVENTION						
	Mean	**Median**	**S.D.**	**IQR**	**Mean**	**Median**	**S.D.**	**IQR**	**P-Value*** *(Median)*	**P-Value*** *(Mean)*	**Difference**
RX Costs	$469	$208	950.08	586.40	$1,074	$863	946.82	1253.86	**<.001**	**<.001**	$605
ED Costs	$149	$0	258.41	246.50	$236	$0	418.78	390.14	0.081	0.126	$87
IP Costs	$334	$0	1202.48	0.00	$203	$0	733.76	0.00	0.246	0.205	-$131
OP Costs	$74	$0	109.82	104.79	$246	$142	259.71	414.91	**<.001**	**<.001**	$172
Total Medical Costs	$1,026	$378	1717.53	958.66	$1,759	$1,434	1744.96	1869.62	**<.001**	**<.001**	$733

** significance level is .05; independent samples Median test and Mann-Whitney U test*

6.3.3. Difference in Costs Pre – Post

Prescription Costs

There was not a significant difference in the change of the mean cost of asthma-related prescriptions used in the 12 months pre compared to the 12 months post the intervention month, (C=-$16, I=-149, p<.397). Both groups increased their prescription costs slightly (Table 6.13).

When separated into types of asthma-related prescriptions, controller or rescue medications, there is almost a statistically significant difference in the change in costs of controller medications between the two groups between the two time periods, with the intervention group increasing its use of controller medications four times as much as the control group (C=-$57, I=-$260, p=<.055). The change in the cost of controller medications increased by $204 in the intervention group as compared to the controller group. The change in the difference of costs of the rescue medications between the two groups was not statistically significant, although the cost of the rescue medications increased by $28 for the intervention group, compared to $3 for the control group, for a net change of $25 more for the intervention group (C=-$3, I=-$28, p=<.39) participants and a control group (Table 6.12).

Table 6.12: Unadjusted Change in Costs of Asthma-Controller and Rescue Drugs among HHU II participants and a control group

	CONTROL				INTERVENTION					
	Mean	**Median**	**S.D.**	**IQR**	**Mean**	**Median**	**S.D.**	**IQR**	**P-Value*** *(Mean)*	**Net Cost****
RX Controller Costs	$57	$0	526.86	361.93	$260	$102	526.86	361.93	**0.055**	$204
RX Rescue Costs	$3	-$4	89.63	83.00	$28	$14	137.79	155.93	0.394	$25

* Significance level is .05; independent samples Mann-Whitney U test

** Relative cost increase of intervention vs. control

ED Costs

There was no significant difference in the change of the mean cost (C=$236, I=$245, p=.626) of asthma-related emergency department visits between the two groups, during the two time periods**.** However, both groups averaged a similar decrease in the mean cost of their ED visits during the post-intervention period.

Inpatient Costs

There was no significant difference in the change of the mean cost (C=$1025, I=$964, p=.174) of asthma-related emergency department visits between the two groups, during the two time periods**.** Both groups experience a decrease in the average cost of inpatient stays during the post intervention time period of almost $1000 during the 12 month post intervention period.

Outpatient Costs

There was no significant difference in the change of the mean cost (C=-3, I=26, p=.859) of asthma-related outpatient visits between the two groups, during the two time periods**.** The intervention group experienced an average savings of $26, while the control group increased its average cost by $3.

Total Medical Costs

There was no statistically significant difference in the change of the total medical cost (C=$1241, I=1085, p=.24) of all asthma-related prescription, emergency department, inpatient and outpatient costs between the two groups, during the two time periods**.** The intervention group experienced an average savings of $1085, while the control group experienced an average savings of $1241. The control group experienced a net savings of $156 greater than the intervention group (Table 6.13).

Table 6.13: Unadjusted Change in Costs of Asthma-related Care among HHU II participants and a control group

	CONTROL				INTERVENTION						
	Mean	Median	S.D.	IQR	Mean	Median	S.D.	IQR	P-Value* *(Median)*	P-Value* *(Mean)*	Difference
RX Costs	-$16	$18	526.77	409.23	-$149	-$33	661.18	789.42	0.846	0.397	-$133
ED Costs	$236	$197	392.63	336.74	$245	$263	505.60	545.71	0.333	0.607	$10
IP Costs	$1,025	$0	4234.56	0.00	$964	$0	1980.05	2366.64	0.183	0.174	-$61
OP Costs	-$3	$0	112.49	141.58	$26	$0	270.99	312.55	0.638	0.859	$29
Total Difference in Costs	$1,241	$262	4342.04	861.84	$1,085	$641	1875.19	1764.06	0.175	0.24	-$156

* significance level is .05; independent samples Median test and Mann-Whitney U test

6.3.4. General linear regression

General linear regression was used to determine any changes in utilization during the pre and post periods, adjusting for age at baseline, race, and gender. The mean and standard error were reported for the control and intervention groups, and a significance test at p <.05.

Utilization

Prescription Use

There was no statistically significant change in the overall utilization of asthma-related prescriptions (Table 6.14) between the control and intervention group between the two periods. The slope coefficient for dependent variable is group is positive, indicating that going from control group to intervention group increases the change in utilization of the number of asthma-related scripts. The gender predictor is also positive, indicating that going from male to female increases the change in utilization of asthma-related scripts, although the change is not statistically significant. The race variables for black (race =1) and white (race =2) are also positive, indicating an increased change in utilization as compared to the 'other' category. The Hispanic group (race = 3) coefficient is negative, indicating a decrease in change in utilization as compared to the 'other' race group. Age at baseline is statistically different between the intervention and control groups, indicating that as age increases, it has a positive effect on a change in utilization of asthma-related prescriptions overall.

Table 6.14: Multivariate Results Change in Utilization of Asthma-related RX filled between Pre and Post Period

			Parameter estimates				
			Interval		*Hypothesis Test*		
Parameter	*B*	*S.E.*	*Lower*	*Upper*	*Wald Chi-Square*	*df*	*Sig.*
(Intercept)	-4.428	2.2817	-8.900	.044	3.766	1	.052
[Group=0]	1.046	1.0364	-.986	3.077	1.018	1	.313
[Group=1]	0[a]						
[Gender=0]	.713	.9997	-1.246	2.672	.509	1	.476
[Gender=1]	0[a]						
[Race=1]	1.626	1.9407	-2.178	5.429	.702	1	.402
[Race=2]	1.277	1.9846	-2.613	5.167	.414	1	.520
[Race=3]	-.224	2.5844	-5.290	4.841	.008	1	.931
[Race=4]	0[a]						
Age_Baseline	.246	.1066	.037	.455	5.334	1	.021
(Scale)	25.796[b]	3.3302	20.029	33.223			

Dependent Variable: Difference between Pre_RX_NumScripts and Post_RX_NumScripts
Model: (Intercept), Group, Gender, Race, Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is much larger than its df (Table 6.15). Therefore, observed values deviate significantly from expected values.

Table 6.15: Multivariate Results GLM: Change in Utilization of Asthma-related RX filled between Pre and Post Period : Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	3095.504	113	27.934

Controller Medications

There was a statistically significant change in the overall utilization of asthma-related controller prescriptions (Table 6.16) between the control and intervention group between the two periods. The slope coefficient for dependent variable is group is positive, indicating that going from control group to intervention group increases the change in utilization of the number of asthma-related controller scripts which were filled. The gender predictor is also positive, indicating that going from male to female increases the change in utilization of asthma-related controller scripts, although the change is not statistically significant. The race variables for black (race =1) and white (race =2) are also positive, indicating an increased change in utilization as compared to the ‘other’ category. The Hispanic group (race = 3) coefficient is negative, indicating a decrease in change in utilization as compared to the ‘other’ race group. Age at baseline is statistically significant between the intervention and control groups, indicating that as age increases it has a positive effect on a change in utilization of asthma-related controller prescriptions overall.

Table 6.16: Multivariate Results GLM: Change in Utilization of Asthma-Controller RX filled between Pre and Post Period

Parameter estimates

Parameter	*B*	*S.E.*	*Interval*		*Hypothesis Test*		
			Lower	*Upper*	*Wald Chi-Square*	*df*	*Sig.*
(Intercept)	-3.602	1.3607	-6.269	-.935	7.006	1	.008
[Group=0]	1.249	.6182	.037	2.460	4.079	1	.043
[Group=1]	0[a]						
[Gender=0]	.327	.5969	-.843	1.497	.300	1	.584
[Gender=1]	0[a]						
[Race=1]	1.143	1.1544	-1.119	3.406	.981	1	.322
[Race=2]	.148	1.1813	-2.167	2.463	.016	1	.900
[Race=3]	-.391	1.5350	-3.400	2.617	.065	1	.799
[Race=4]	0[a]						
Age_Baseline	.156	.0638	.031	.282	6.004	1	.014
(Scale)	9.091[b]	1.1836	7.044	11.734			

Dependent Variable: Difference between Pre_RX_Cont_NumScripts and Post_RX_Cont_Num Scripts
Model: (Intercept), Group, Gender, Race,
Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is larger than its df (Table 6.17). Therefore, observed values deviate significantly from expected values.

Table 6.17: Multivariate Results GLM: Change in Utilization of Asthma-Controller RX filled between Pre and Post Period: Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	1072.78	111	9.66

Reliever medications

There was not a statistically significant change in the overall utilization of asthma-related reliever prescriptions (Table 6.18) between the control and intervention group between the two periods. The slope coefficient for dependent variable is group is positive, indicating that going from control group to intervention group increases the change in utilization of the number of asthma-related controller scripts which were filled. The gender predictor is also positive, indicating that going from male to female increases the change in utilization of asthma-related controller scripts, although the change is not statistically significant. The race variables for black (race =1) and white (race =2) are also positive, indicating an increased change in utilization as compared to the ‘other’ category. The Hispanic group (race = 3) coefficient is negative, indicating a decrease in change in utilization as compared to the ‘other’ race group. Age at baseline is not statistically different between the intervention and control groups, and has a minimal effect on a change in utilization of asthma-related rescue prescriptions overall.

Table 6.18: Multivariate Results GLM: Change in Utilization of Asthma-Rescue RX filled between Pre and Post Period

Parameter estimates

Parameter	*B*	*S.E.*	*Interval* *Lower*	*Upper*	*Hypothesis Test* *Wald Chi-Square*	*df*	*Sig.*
(Intercept)	-1.686	1.4672	-4.562	1.189	1.321	1	.250
[Group=0]	.466	.6665	-.840	1.772	.489	1	.484
[Group=1]	0[a]						
[Gender=0]	.371	.6436	-.890	1.633	.333	1	.564
[Gender=1]	0[a]						
[Race=1]	.075	1.2447	-2.364	2.515	.004	1	.952
[Race=2]	.786	1.2737	-1.710	3.283	.381	1	.537
[Race=3]	-.728	1.6550	-3.972	2.516	.194	1	.660
[Race=4]	0[a]						
Age_Baseline	.098	.0688	-.037	.233	2.030	1	.154
(Scale)	10.570[b]	1.3760	8.189	13.642			

Dependent Variable: Difference between Pre_RX_Rescue_NumScripts and Post_RX_Rescue_NumScripts
Model: (Intercept), Group, Gender, Race, Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is larger than its df (Table 6.19). Therefore, observed values deviate significantly from expected values.

Table 6.19: Multivariate Results GLM: Change in Utilization of Asthma-Rescue RX filled between Pre and Post Period: Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	1247.21	111	11.24

ED Use

There was no statistically significant change in the overall utilization of asthma-related emergency department visits (Table 6.20) between the control and intervention group between the two periods. The slope coefficient for dependent variable is group is negative, indicating that going from control group to intervention group decreases the change in utilization of the number of asthma-related emergency department visits. The gender predictor is also negative, indicating that going from male to female decreases the change in utilization of emergency department visits, although the change is not statistically significant. The race variables for black (race =1), white (race =2), and Hispanic (race=3) are also negative, and statistically significant, indicating a decreased change in utilization of the emergency department as compared to the ‘other’ category for all race groups. Age at baseline is not statistically different between the intervention and control groups, having almost no effect on a change in utilization of asthma-related emergency department visits overall.

Table 6.20: Multivariate Results GLM: Change in Utilization of Asthma-related ED visits between Pre and Post Period

Parameter estimates

Parameter	*B*	*S.E.*	*Interval* *Lower*	*Upper*	*Hypothesis Test* *Wald Chi-Square*	*df*	*Sig.*
(Intercept)	2.947	.6511	1.671	4.223	20.489	1	.000
[Group=0]	-.082	.2957	-.661	.498	.076	1	.783
[Group=1]	0[a]						
[Gender=0]	-.048	.2853	-.607	.511	.029	1	.865
[Gender=1]	0[a]						
[Race=1]	-2.166	.5538	-3.252	-1.081	15.304	1	.000
[Race=2]	-2.032	.5663	-3.142	-.922	12.869	1	.000
[Race=3]	-2.964	.7375	-4.409	-1.518	16.149	1	.000
[Race=4]	0[a]						
Age_Baseline	.009	.0304	-.051	.069	.087	1	.768
(Scale)	2.101[b]	.2712	1.631	2.705			

Dependent Variable: Difference between Pre_ED_Visits and Post_ED_Visits
Model: (Intercept), Group, Gender, Race, Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is larger than its df (Table 6.21). Therefore, observed values deviate significantly from expected values.

Table 6.21: Multivariate Results GLM: Change in Utilization of Asthma-related ED visits between Pre and Post Period: Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	252.07	113	2.23

Inpatient Stays

There was a statistically significant change in the overall utilization of asthma-related inpatient stays (Table 6.22) between the control and intervention group between the two periods. The slope coefficient for dependent variable is group is negative, indicating that going from control group to intervention group decreases the change in utilization of the number of asthma-related inpatient stays. The gender predictor is positive but very small, indicating that going from male to female increases the change in utilization of asthma-related inpatient stays very little, and the change is not statistically significant. The race variables for black (race =1) and white (race =2) are also positive, indicating an increased change in utilization of inpatient stays as compared to the 'other' category, although the difference is not statistically significant. The Hispanic group (race = 3) coefficient is negative, indicating a decrease in change in utilization of asthma related inpatient stays as compared to the 'other' race group. Age at baseline is not statistically different between the intervention and control groups, and has a small negative effect on a change in utilization of asthma-related prescriptions overall.

The change in inpatient stays is significant at $p<.05$ (C=0.0, I=0.32, p=.006) (Tables 6.22, 6.23).

Table 6.22: Multivariate Results GLM: Change in Utilization of Asthma-related IP visits between Pre and Post Period

			Parameter estimates				
			Interval		*Hypothesis Test*		
Parameter	*B*	*S.E.*	*Lower*	*Upper*	*Wald Chi-Square*	*df*	*Sig.*
(Intercept)	.333	.2517	-.161	.826	1.748	1	.186
[Group=0]	-.315	.1143	-.539	-.091	7.578	1	.006
[Group=1]	0[a]						
[Gender=0]	.019	.1103	-.197	.235	.030	1	.863
[Gender=1]	0[a]						
[Race=1]	.142	.2141	-.278	.561	.438	1	.508
[Race=2]	.193	.2190	-.236	.623	.781	1	.377
[Race=3]	-.045	.2851	-.604	.514	.025	1	.874
[Race=4]	0[a]						
Age_Baseline	-.016	.0118	-.039	.007	1.857	1	.173
(Scale)	.314[b]	.0405	.244	.404			

Dependent Variable: Difference between Pre_IP_visits_count and Post_IP_visits_count
Model: (Intercept), Group, Gender, Race, Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is smaller than its df (Table 6.23) and is nearing zero. Therefore, observed values nearly equal expected values, and confirm the validity of the model.

Table 6.23: Multivariate Results GLM: Change in Utilization of Asthma-related IP stays between Pre and Post Period: Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	37.68	113	0.33

Outpatient Visits

There was almost a statistically significant change in the overall utilization of asthma-related outpatient visits (Table 6.24) between the control and intervention group between the two periods (P =.068). The slope coefficient for the dependent variable is group is negative, indicating that going from control group to intervention group decreases the change in utilization of the number of asthma-related outpatient visits. The gender predictor is also positive, indicating that going from male to female increases the change in utilization of asthma-related scripts, although the change is not statistically significant. The race variables for black (race =1), white (race =2) and Hispanic (race=3) are also positive, indicating an increased change in utilization as compared to the 'other' category, but it is not statistically significant. The Hispanic group (race = 3) coefficient is negative, indicating a decrease in change in utilization as compared to the 'other' race group. Age at baseline is not statistically different between the intervention and control groups, but indicates a small positive effect on a change in utilization of asthma-related outpatient visits overall.

Table 6.24: Multivariate Results GLM: Change in Utilization of Asthma-related OP visits between Pre and Post Period

Parameter estimates

Parameter	*B*	*S.E.*	*Interval* *Lower*	*Upper*	*Hypothesis Test* *Wald Chi-Square*	*df*	*Sig.*
(Intercept)	-.398	.8740	-2.110	1.315	.207	1	.649
[Group=0]	-.725	.3970	-1.503	.053	3.336	1	.068
[Group=1]	0[a]						
[Gender=0]	.500	.3829	-.250	1.251	1.706	1	.192
[Gender=1]	0[a]						
[Race=1]	.575	.7433	-.882	2.032	.598	1	.439
[Race=2]	1.015	.7601	-.474	2.505	1.784	1	.182
[Race=3]	.073	.9899	-1.867	2.013	.005	1	.941
[Race=4]	0[a]						
Age_Baseline	.020	.0408	-.060	.100	.250	1	.617
(Scale)	3.784[b]	.4886	2.938	4.874			

Dependent Variable: Difference between Pre_OP_Visits and Post_OP_Visits
Model: (Intercept), Group, Gender, Race, Age_Baseline
b. Maximum likelihood estimate.

The chi square statistic is larger than its df (Table 6.25). Therefore, observed values deviate significantly from expected values, and indicate that the model is not optimum.

Table 6.25: Multivariate Results GLM: Change in Utilization of Asthma-related OP visits between Pre and Post Period: Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	454.13	113	4.02

Summary

In summary, the change in inpatient visits is statistically significant at $p<.05$ (C=-0.00, I=0.32, p=.006) and the change in outpatient visits is borderline significant at $p<.10$ (C=-0.33, I=0.39, p=.068) (Table 6.26). The change in outpatient visits had not been significant when not adjusting for age at baseline, race and gender (Table 6.7).

There was a statistically significant change in the overall utilization of asthma-related controller prescriptions between the two groups, which remained significant when adjusting for age at baseline, race and gender (Table 6.16).

Table 6.26: Multivariate Results Change in Utilization of Asthma-related services and care between Pre and Post Period

	Beta	CONTROL		INTERVENTION		
		Mean	Std. Error	Mean	Std. Error	P-Value
Change in Prescriptions Filled	1.05	-0.85	0.80	-1.90	0.95	0.313
Change in ED visits	-0.08	1.11	0.23	1.19	0.27	0.783
Change in IP visits	-0.31	0.00	0.09	0.32	0.10	**0.006**
Change in OP visits	-0.73	-0.33	0.31	0.39	0.36	**0.068**

Dependent Variable: Difference; Significance at .05
Model: (Intercept), Group, Gender, Race, Age_Baseline

Costs

General linear regression was used to determine any changes in total medical care costs during the pre and post periods, adjusting for age at baseline, race, and gender. The mean and standard error were reported for the control and intervention group, and a significance test at p <.05. None of the medical cost types, individually or in unison, showed a statistically significant difference over the two time periods (Table 6.27).

Table 6.27: Multivariate Results Adjusted Costs of Asthma-related Care among HHU II participants and a control group

	Coefficient	S.E.	CONTROL		INTERVENTION		
			Mean	Std. Error	Mean	Std. Error	P-Value*
RX Costs	**$104**	**113.23**	-85.16	87.64	-188.72	103.62	0.360
ED Costs	**-$50**	**83.584**	301.56	64.70	351.20	76.49	0.553
IP Costs	**-$31**	**727.19**	1076.72	562.88	1108.07	665.50	0.553
OP Costs	**-$18**	**35.935**	-13.35	27.82	5.10	32.89	0.608
Total Medical Costs	**$4**	**742.24**	1279.77	574.53	1275.65	679.27	0.996

Dependent Variable: Difference; Significance at .05
Model: (Intercept), Group, Gender, Race, Age_Baseline

There was virtually no change in the overall total cost of asthma-related medical care (Table 6.27) between the control and intervention group between the two periods (C=$1280, I=$1276, P=.996). The slope coefficient for the dependent variable group is positive, indicating that going from control group to intervention group increases the overall asthma-related medical costs by $4 (Table 6.28). The gender predictor is also negative by $595, indicating that going from male to female decreases the change in utilization of asthma-related scripts, although the change is not statistically significant. The race variables for black (race =1), white (race =2) and Hispanic (race=3) are all negative, indicating an increased change in utilization as compared to the 'other' category, but it is not statistically significant. Age at baseline is not statistically different between the intervention and control groups, but indicates a small negative effect on the overall change in costs of asthma-related care.

Table 6.28: Multivariate Results GLM: Change in Costs of Asthma-related Medical Care between Pre and Post Period

Parameter	*B*	*S.E.*	*Lower*	*Upper*	*Wald Chi-Square*	*df*	*Sig.*
(Intercept)	2866.181	1634.1630	-336.720	6069.081	3.076	1	.079
[Group=0]	4.130	742.2435	-1450.641	1458.900	.000	1	.996
[Group=1]	0[a]						
[Gender=0]	-594.859	715.9639	-1998.122	808.404	.690	1	.406
[Gender=1]	0[a]						
[Race=1]	-933.033	1389.9127	-3657.212	1791.145	.451	1	.502
[Race=2]	-530.442	1421.3622	-3316.260	2255.377	.139	1	.709
[Race=3]	-1671.769	1850.9314	-5299.528	1955.990	.816	1	.366
[Race=4]	0[a]						
Age_Baseline	-83.491	76.3770	-233.187	66.205	1.195	1	.274
(Scale)	13231773.353[b]	1708214.5945	10273736.115	17041495.332			

Model: (Intercept), Group, Gender, Race, Age_Baseline

a. Set to zero because this parameter is redundant.

b. Maximum likelihood estimate.

The chi square statistic is extremely large, thousands of times larger than its df (Table 6.29). Therefore, observed values deviate significantly from expected values, and indicate that the model is not predictive at all.

Table 6.29: Multivariate Results GLM: Change in Costs of Asthma-Rescue RX filled between Pre and Post Period Goodness of Fit

	Value	df	Value/df
Pearson Chi-Square	1587812802.31	113	14051440.73

Utilization

A comparison of means for the change in utilization between the two control and intervention groups was conducted. There were no statistically significant changes in means of utilization between the two groups with the outliers removed (Table 6.30).

The dataset had a non-normal distribution. For this analysis, for each type of medical care (RX scripts filled, emergency department visits, inpatient stays, and outpatient visits) the extreme observations were excluded. For each variable of interest, outliers were removed for that specific interest area, and noted in the table (Table 6.30).

Table 6.30: Comparison of Means of Utilization of Asthma-related Services and Care between Pre and Post Period with Exclusion of Outliers

	# outliers	CONTROL		INTERVENTION		
	removed	Mean	S.E.	Mean	S.E.	p-value*
Change in Prescriptions Filled	**2**	-0.10	0.54	-1.29	0.93	0.240
Change in Number of Emergency Department '	**1**	0.84	0.14	0.78	0.26	0.838
Change in Number of Inpatient Visits	**n/a**	*Not calculated no outliers excluded*				
Change in Number of Outpatient Visits	**1**	-0.01	0.16	0.74	0.46	0.127

NOTE: Removed the following cases for this analysis:
Prescriptions Filled: Case 38, 115 (Pre>25, Post >27)
Emergency Department Visits: Case 57,(Pre > 5)
Inpatient Stays: none
Outpatient Visits: Case 113, (Post > 7)

***Significance at .05**

Costs

Similarly, a comparison of means for the change in costs between the two groups was conducted, with the respective outliers removed for each variable of interest in the analysis (Table 6.31). With all the outliers removed, the total difference in change of all medical costs together approached significance at p<.1, (C=$470, I=968, p=.110). The intervention group cost $498 per case less on medical costs than the control group.

Table 6.31: Comparison of Means of Asthma-Related Costs with Exclusion of Outliers

	# outliers removed	CONTROL Mean	CONTROL S.E.	INTERVENTION Mean	INTERVENTION S.E.	P-Value	Benefit
Difference between Post and Pre Period RX Costs	**1**	$10	53.45	-$149	313.07	0.26	-$160
Difference between Post and Pre Period ED Costs	**1**	$236	43.90	$256	81.34	0.66	$20
Difference between Post and Pre Period IP Costs	**2**	$399	181.35	$964	104.54	0.08	$564
Difference between Post and Pre Period OP Costs	**0**	*Not calculated no outliers excluded*					
Total Difference in Post and Pre Medical Costs	**5**	$470	168.80	$968	279.15	0.11	$498

NOTE: Removed the following cases for this analysis:
Prescription Costs: Case 38 (Pre>$5700, Post>$7700)
Emergency Department Costs: Case 39 (Post>$1800)
Inpatient Costs: Cases 59,67 (Pre=>$25,000)
Outpatient Costs: None
Total Medical Costs: Case 20,38,47,59,67 (Pre >$15,000, Post, >$7000)

6.3.5. General linear regression with exclusion of outliers

Costs

General linear regression was used to determine any changes in medical care costs during the pre and post periods, adjusting for age at baseline, race, and gender. The mean and standard error were reported for the control and intervention group, and a significance test was conducted at p <.05. Each of the types of medical care were run separately. One of the medical cost types, inpatient costs, showed a statistically significant difference over the two time periods with the outliers removed (C=$513, I=$1207, p<.042). The difference in total medical costs was close to statistical significance (C=$347, I=$946, p<.052), with the intervention group saving $620 over the control group during the two time periods, with the outliers excluded (Table 6.32). The individual regression tables for each cost type are presented as follows: RX costs (Table 6.33), ED costs (Table 6.34), IP costs (Table 6.35), and overall Medical costs

(Table 6.36).

Table 6.32: Multivariate Results Adjusted Costs of Asthma-related Care among HHU II participants and a control group with outliers removed

	# Outliers removed	Beta	S.E.	CONTROL		INTERVENTION			
				Mean	S.E.	Mean	S.E.	P-Value*	Difference
RX Costs	1	-137.31	108.04	-$64	83.49	-$201	98.59	0.204	-$137
ED Costs	1	61.27	84.60	$298	64.87	$359	77.02	0.469	$61
IP Costs	2	693.82	341.72	$513	265.12	$1,207	311.43	0.042	$694
OP Costs	n/a								
Total Costs	5	619.62	318.90	$347	254.36	$966	295.09	0.052	$620

Dependent Variable: Difference; Significance at .05

Model: (Intercept), Group, Gender, Race, Age_Baseline

Table 6.33: Multivariate Results Difference between Pre-RX Costs and Post-RX Costs of Asthma-related Care among HHU II participants with RX outliers removed

Dependent Variable: Difference between Pre_RX_Costs and Post_RX_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	-411.403	237.1390	-876.187	53.380	3.010	1	.083
[Group=0]	137.311	108.0414	-74.447	349.068	1.615	1	.204
[Group=1]	0[a]						
[Race=1]	143.703	201.6418	-251.508	538.914	.508	1	.476
[Race=2]	131.507	206.8701	-273.951	536.965	.404	1	.525
[Race=3]	-61.599	268.6554	-588.154	464.956	.053	1	.819
[Race=4]	0[a]						
[Gender=0]	37.992	103.9730	-165.792	241.775	.134	1	.715
[Gender=1]	0[a]						
Age_Baseline	22.422	11.1324	.603	44.241	4.057	1	.044
(Scale)	278363.611[b]	36087.2658	215904.681	358891.244			

Dependent Variable: Difference between Pre_RX_Costs and Post_RX_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline

a. Set to zero because this parameter is redundant.

b. Maximum likelihood estimate.

Table 6.34: Multivariate Results Difference between Pre-ED Costs and Post-ED Costs of Asthma-related Care among HHU II participants with ED outliers removed

Dependent Variable: Difference between Pre_ED_Costs and Post_ED_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	742.134	184.4103	380.697	1103.572	16.196	1	.000
[Group=0]	-61.268	84.6054	-227.091	104.556	.524	1	.469
[Group=1]	0[a]						
[Race=1]	-517.379	156.8197	-824.740	-210.018	10.885	1	.001
[Race=2]	-482.928	160.1776	-796.871	-168.986	9.090	1	.003
[Race=3]	-602.933	208.6500	-1011.880	-193.987	8.350	1	.004
[Race=4]	0[a]						
[Gender=0]	-.385	80.8313	-158.811	158.042	.000	1	.996
[Gender=1]	0[a]						
Age_Baseline	2.930	8.6305	-13.985	19.845	.115	1	.734
(Scale)	168025.181[b]	21782.9096	130323.871	216633.080			

Dependent Variable: Difference between Pre_ED_Costs and Post_ED_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

Table 6.35: Multivariate Results Difference between Pre-IP Costs and Post-IP Costs of Asthma-related Care among HHU II participants with IP outliers removed

Dependent Variable: Difference between Pre_IP_Costs and Post_IP_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	2662.346	751.3301	1189.766	4134.926	12.556	1	.000
[Group=0]	-693.823	341.7182	-1363.579	-24.068	4.123	1	.042
[Group=1]	0[a]						
[Race=1]	-1073.866	637.9945	-2324.312	176.580	2.833	1	.092
[Race=2]	-921.787	652.8117	-2201.274	357.701	1.994	1	.158
[Race=3]	-1525.825	848.5729	-3188.997	137.347	3.233	1	.072
[Race=4]	0[a]						
[Gender=0]	-358.131	333.0459	-1010.889	294.627	1.156	1	.282
[Gender=1]	0[a]						
Age_Baseline	-64.561	35.3168	-133.781	4.658	3.342	1	.068
(Scale)	2778670.276[b]	361752.0573	2152880.943	3586361.118			

Dependent Variable: Difference between Pre_IP_Costs and Post_IP_Costs
Model: (Intercept), Group, Race, Gender, Age_Baseline
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

Table 6.36: Multivariate Results GLM: Change in Costs of Asthma-related Medical Care between Pre and Post Period with outliers removed

Dependent Variable: Sum of Benefit_OP + Benefit_IP + Benefit_ED + Benefit_RX
Model: (Intercept), Group, Race, Gender, Age_Baseline

Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test		
			Lower	Upper	Wald Chi-Square	df	Sig.
(Intercept)	1436.792	741.8072	-17.123	2890.708	3.752	1	.053
[Group=0]	-619.619	318.8962	-1244.644	5.406	3.775	1	.052
[Group=1]	0[a]						
[Race=1]	-237.156	629.3012	-1470.564	996.252	.142	1	.706
[Race=2]	-188.006	642.8375	-1447.944	1071.932	.086	1	.770
[Race=3]	-976.243	811.8837	-2567.505	615.020	1.446	1	.229
[Race=4]	0[a]						
[Gender=0]	-34.460	313.5807	-649.067	580.147	.012	1	.912
[Gender=1]	0[a]						
Age_Baseline	-16.478	32.8900	-80.942	47.985	.251	1	.616
(Scale)	2365594.467[b]	311965.3599	1826783.837	3063327.510			

Dependent Variable: Sum of Benefit_OP + Benefit_IP + Benefit_ED + Benefit_RX
Model: (Intercept), Group, Race, Gender, Age_Baseline
a. Set to zero because this parameter is redundant.
b. Maximum likelihood estimate.

There was no statistical significance of age, gender, or race on the RX costs, OP costs, and IP costs models. However, for the emergency department costs, race was a significant factor in the model. Therefore, the model for total medical costs was run again controlling for race only (Table 6.37). In that model, the difference in total medical costs was statistically significance (C=$337, I=$962, p<.05), with the intervention group saving $624 over the control group during the two time periods, with the outliers excluded (Table 6.37).

Table 6.37: Multivariate Results Adjusted Costs of Asthma-related Care among HHU II participants and a control group

	# Outliers removed	Beta	S.E.	CONTROL		INTERVENTION			
				Mean	S.E.	Mean	S.E.	P-Value*	Difference
Total Medical Costs	5	-$624	319.05	337.90	243.87	962.39	285.28	**0.05**	$624

Dependent Variable: Difference; Significance at .05
Model: (Intercept), Group, Race

6.3.6. Comparisons of Costs Calculations

6.3.6.1. Overall Effect on Medical Costs

When considering the various cost calculations, it is evident that the healthy homes intervention makes very little difference on the overall medical costs incurred (Table 6.38). The unadjusted net benefit is an increase in medical costs of $156, which is not statistically significant (Table 6.13). When a regression model is used, the intervention costs $4 more than the control, and the difference is not statistically significant (Table 6.27). When outliers are removed, the unadjusted net benefit is a savings of $498, but the difference between the groups is not significant (Table 6.31). When outliers are removed and a regression model is used, the savings increases to $620 and the model approaches significance at p=<.05 (Table 6.32). A final regression model with outliers removed which only controls for race, which had been a significant predictor, accounts for a final savings of $624, which is statistically significant at p=<.05 (Table 6.37).

Table 6.38: Comparison of Total Medical Cost Calculations and Net Benefit

	CONTROL		INTERVENTION		P-Value*	Net Benefit
	Mean	S.D.	Mean	S.D.		
Unadjusted Change in Costs (Table 6.13)	$1,241	4342	$1,085	1875	0.240	-$156
Adjusted Change in Costs - Regression (Table 6.27)	$1,280	575	$1,276	679	0.996	-$4
Unadjusted Change in Costs with outliers removed (Table 6.31)	$470	169	$968	279	0.11	$498
Adjusted Change in Costs with outliers removed- Regression (Table 6.32)	$347	254	$966	295	0.052	$620
Adjusted Change in Costs with outliers removed- Regression (Table 6.37)	$338	244	$962	285	**0.5**	$624

*Significant at p=<.05

Table 6.39 represents the average marginal direct and full per person cost for the Healthy Homes University II program participants.

Table 6.39: Healthy Homes University II Average per-Person Marginal, Direct, and Full Costs

	Cost Per Program participant
Marginal	$1,882
Direct	$3,751
Full	$4,832

The difference between the total benefit and the marginal, direct, and full costs were calculated and are displayed in Table 6.40.

Table 6.40: Effect of Marginal, Direct, and Full Costs on Net Benefit

	P-Value*	Net Benefit	Benefit minus Marginal Cost ($1882)	Benefit minus Direct Cost ($3751)	Benefit minus Full Cost($4832)
Unadjusted Change in Costs (Table 6.13)	0.240	-$156	-$2,038	-$3,907	-$4,988
Adjusted Change in Costs (Table 6.27)	0.996	-$4	-$1,886	-$3,755	-$4,836
Unadjusted Change in Costs without outliers (Table 6.31)	0.11	$498	-$1,384	-$3,253	-$4,334
Adjusted Change in Costs without outliers (Table 6.32)	0.052	$620	-$1,262	-$3,131	-$4,212
Adjusted Change in Costs without outliers (Table 6.37)	**0.5**	$624	-$1,258	-$3,127	-$4,208

*Significant at p=<.05

For all scenarios, there is no cost benefit to conducting this healthy homes intervention if evaluating against a potential savings in asthma related medical costs. When compared against the marginal project costs, the benefit ranged from -$1,258 (in a model removing the outliers) to -$2,038 (in a model of unadjusted costs).

When compared against the direct project costs, the benefit ranged from -$3,127 (in a model removing the outliers) to -$3,907 (in a model of unadjusted costs).

When compared against the full project costs, the benefit ranged from -$4,208 (in a model removing the outliers) to -$4,988 (in a model of unadjusted costs).

Chapter 7

Discussion and Policy Implications

Little is known about the cost-benefit of Health Homes Intervention programs to control chronic diseases such as asthma in Michigan. Current reimbursement agreements do not cover the full costs of asthma prevention programs, and none of the existing program in Michigan include best practice 4, the implementation of environmental control measures. One group, the Asthma Network of West Michigan (ANWM) has provided home-based case management services to Priority Health's Medicaid pediatric population on a fee-for-service basis, and also has contracts with four other health plans. The goal of this study was to evaluate the cost implications of an asthma healthy homes intervention in Michigan. The anticipated findings were improved health outcomes and lower health care costs for children with asthma in Michigan.

7.1. Discussion

7.1.1. Utilization

The study considered the change in utilization for four types of health care in children with asthma who participated in the study: asthma controller and reliever use; emergency department visits; inpatient stays; and outpatient visits. The intervention group had higher rates of utilization for all types of medical care during the pre-period, therefore it also had bigger potential for gains in reducing utilization.

Prescription Use

There was a statistically significant difference in the change in asthma controller use, with the intervention group increasing its use of controller medications four times as much as the control group (Chapter 6; Tables 6.7, 6.16). The intervention group increased its use of rescue medication more than the control group, although the finding was not significant (Chapter 6, Table 6.18). These findings compare to the Kattan study (2005), where participants increased their use of anti-inflammatory medication and cromolyn inhalers; in that study they also decreased their use of inhalers used per year by 2. The fact that controller medications increased significantly in the intervention population shows that the educational components of the intervention was effective.

Emergency department visits

There was no significant decrease in asthma-related emergency department use between the groups. Other studies have found decreases in emergency department use, such as Kercsmar (2006), Krieger (2005), Kattan (2005), and Sullivan (2002). The Kattan, Kreiger, and Sullivan studies were randomized controlled trials which all included minor rehabilitative work; the Krieger study compared a high intensity intervention against a low intensity intervention, and the Sullivan study was focused on education and self-management, delivered by Asthma counselors.

Inpatient utilization

There was a statistically significant decrease in the mean number of inpatient stays; the intervention group started off with higher relative number (twice as many) of IP stays than the controls, and reduced it to 1/4 as many, a very significant reduction (Chapter

6; Tables 6.7, 6.22). The intervention group experienced half as many stays during the post-intervention period as the control group. This finding was consistent with Kercsmar (2005) and Krieger (2005), whose findings were also statistically significant, and also with Kattan (2005) and Sullivan (2002), with similar findings but which were not statistically significant.

Outpatient utilization

The intervention group started off with three times as many outpatient visits as the control group, and reduced to twice as outpatient visits as the control group, which was more than proportional, although not statistically significant. The Generalized Linear Model approached significance at p=<.068 (Chapter 6, Table 6.24). Outman (2007) demonstrated a statistically significant reduction in unscheduled visits in the evaluation of an intervention that provided basic remediation, coupled with visits by an asthma educator/respiratory therapist. Krieger (2005) also demonstrated a statistically significant reduction in unscheduled clinic visits.

Other utilization considerations

In the Michigan Asthma Call-Back survey [21], 51% of children with current asthma had not used a long term controller medication in the past 3 months. The fact that the HHUII study had a significant impact on the use of long-term controllers (Chapter 6, Table 6.12) is an important and desired finding, as the unadjusted change in the costs of controller medications approached significance (C=$57, I=$260, P=<.055). A stated goal of the study was to determine if it had a decreasing effect on the cost of rescue medications; unfortunately, these costs increased for the intervention group, but not for the control group, but the finding was not significant.

7.1.2. Medical Costs

Emergency Department Costs

There was no significant difference in the change of the mean cost of asthma-related ED visits. In a general linear model of emergency department visits, race was a significant factor in explaining variation in ED visits.

Inpatient Costs

There was no significant difference in the change of the mean cost of asthma-related IP stays. A generalized linear model showed statistical significance of inpatient costs with the removal of outliers ($C=$513, I=$1207, p<.042) (Table 6.32).

Outpatient Costs

There was no significant change in the mean cost of asthma related outpatient visits.

Total Medical Costs

Krieger (2005), Kattan (2005), and Sullivan (2002) all showed a range of medical costs averted between $124 and $155, compared with program costs which ranged between $458 and $1316.   In the HHUII study, none of the medical cost types showed a statistically significant difference in cost in either direction after the intervention, in fact there was virtually no change (C=$1289, I=$1276, p=.996), with the intervention group costing $4 more (Table 6.27). With the outliers removed, the total difference in change of all the medical costs together approached significance at p=<.1 (C=$470, I=$968, p=.110), a savings of $498 more for the intervention group (Table 6.31). A generalized linear model of total medical costs was close to statistical significance with the outliers removed ($C=$347, I=$946, p<.052) (Table 6.32), a savings of $620 for the intervention group. When a general linear model with outliers removed was run for medical costs controlling for race only, the difference was significant, with the intervention saving $624 over the control group(C=$337, I=$962, p=<.05) (Chapter 6, Table 6.37). These results are comparable to the Krieger (2005), Kattan (2005), and Sullivan (2002) results.

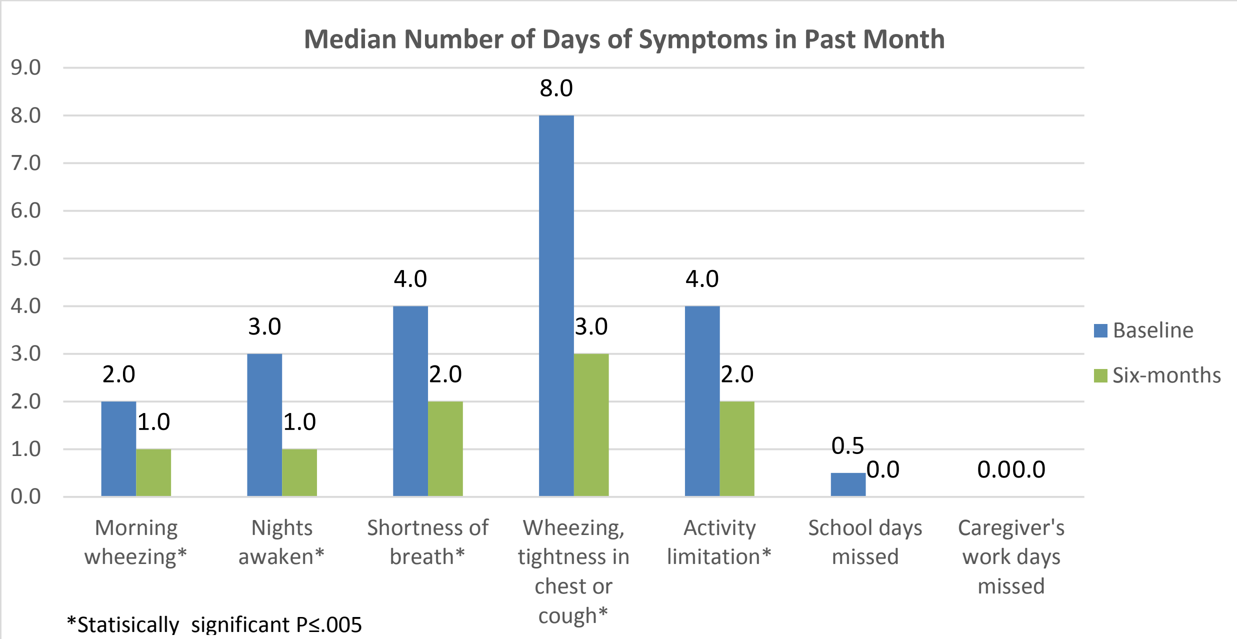
7.1.3. Other cost considerations

Quality of Life

A major limitation of this study was its ability to quantify and assign a value to the effects that the intervention had on quality of life. The asthma call-back survey [21] provides a comprehensive look at the current effect asthma is having on children's quality of life in Michigan; 17% of children experience symptoms 9+ days per month; 10% of children have difficulty sleeping 2+ days per month; 12% of children experience asthma every day of the past two weeks; 55% of children limited usual activities due to asthma during the past 12 months; 17% of children missed 6 or more school days in the past 12 months.

In the HHU II study [55], caregivers did report monthly frequencies for subject children experiencing negative health effects due to asthma as shown in Figure 7.1.

Figure 7.1*: Median Number of Days of Symptoms in Past Month



Median number of days of symptoms in the past month at Baseline and Six-months. Figure* provided by Healthy Homes University II, [55]

Quality of life was assessed using the caregiver version of the validated *Asthma Quality of Life Questionnaire (AQLQ)*. The Caregiver AQLQ [56] contains 13 questions and response categories range from 1 (All of the time or very, very worried/concerned) to 7 (None of the time or Not worried/concerned). The score was calculated for both Baseline and Six-months. If a person's median score improves by 0.5, it is considered a significant indicator of improvement. All of the findings were based on self-report. For each of the listed indicators of asthma impact, the number of monthly occurrences reported at six months was less than reported at baseline with the exception of missed school and work days. The reductions seen in the proportion of individuals morning wheezing; nights awakened; shortness of breath, wheezing, tightness in chest or cough;

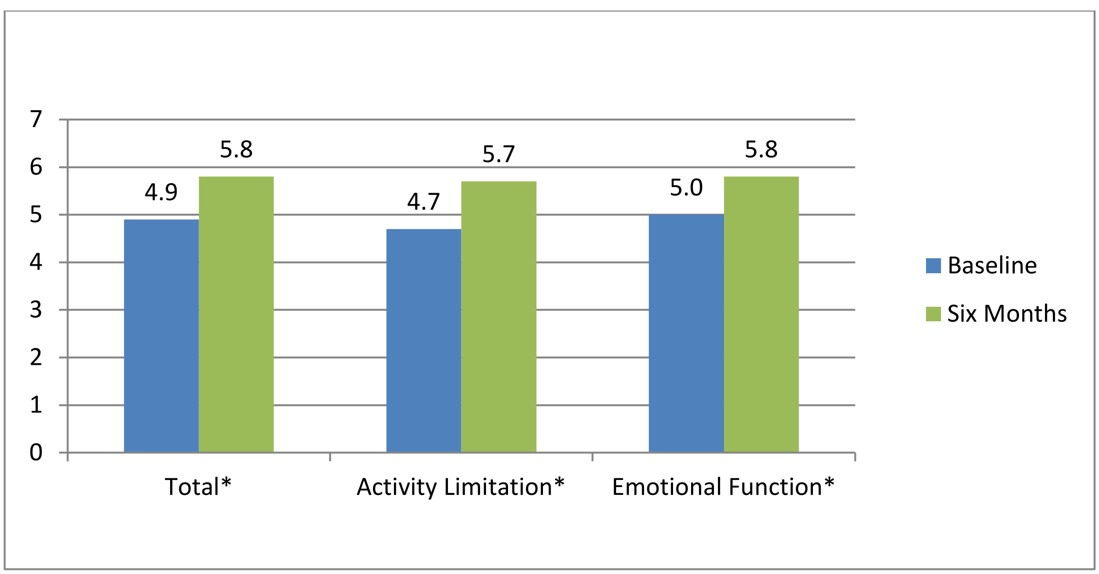
or activity limitation were statistically significant (P<.005, P<.0001, P<.0001 and P<.0001, respectively).

School and Work days missed

The HHU II program reported [55] a 0.5 day reduction in the mean number of days missed from school due to asthma in the six-months prior to completion as compared to the six-months prior to Baseline, however, this reduction was not statistically significant. Only 73 of the 183 participants reported that they worked outside the home. There was no change in median number of missed work days from Baseline to Six-months (Figure 7.1).

Caregiver participants also reported questions pertaining to their quality of life. There was a statistically significant increase in emotional function and decreases in activity limitation (Figure 7.2).

Figure 7.2*: Asthma Quality of Life Survey



Caregiver participant pre/post asthma quality of life mean number of days score results (N=164). Figure* provided by Healthy Homes University II, [55]

7.1.4. Cost-benefit considerations

The study did not find a net change in the costs of asthma related medical care. The finding were flat (-$4). With outliers removed, the net change in the costs of asthma related medical care was $624. These findings are consistent with the findings of previous researchers (Table 7.1) who have attempted to demonstrate the cost-benefit of healthy homes interventions in programs with minor (provision of advice on recommended environmental changes and may include provision of low-cost items such as mattress and pillow allergen-impermeable covers) or moderate (provision of low cost materials, active involvement of a trained home visitor, installation of low-cost items including sair filters and dehumidifiers, integrated pest management, professional cleaning services, and minor repairs of structural integrity) environmental trigger education and mitigation [57-59]. All three studies had a benefit-cost ration between 0.9 and 0.32, indicating that the program costs were significantly more than the direct medical costs averted, which ranged from $124-$555.

Table 7.1: Results of Selected Studies of Home-based, Multi-Component Environmental Interventions to Reduce Asthma Morbidity*

	Summary of Per-Participant Economic Information		
Study	**Program Cost ($)**	**Direct medical costs averted ($)**	**Net Cost ($)**
Studies with major rehabilitation work			
Barton (2007)	$14,858	Not reported	
Sommerville (2000)	$6,424	Not reported	
Kercsmar(2006)	$3,796	Not reported	
Studies with minor rehabilitation work			
Krieger(2005)	$1,316	$124-$147	$1192-$1169
Kattan (2005)	$1,720	$555	$1,165
Sullivan (2002)	$458	$147	$311
Healthy Homes University II			
Adjusted costs	$1,882	-$4	$1,886
Adjusted costs without outliers	$1,882	$624	$1,258

*Studies summarized by Nurmagambetov, 2011, except for present HHU II study

Quality of life measures made in this study did not measure symptom free-days. Assuming that symptom-free days measures were available, at a benefit of $20 per symptom-free day, participant in the program would have to have 94 ($1882 divided by $20) symptom free days per year, which were previously not symptom free, in order to make a case for the costs effectiveness of the study based on that criteria.

Some studies have reported benefit-cost ratios ranging from 5.3-14.0 [60-62]. All three of those studies were pre-post design, and had very low ($377-721) program costs per participant. The Oatman, Jowers, and Shelledy studies had a strong focus on certified asthma educators, nurses, or respiratory therapists providing patient education, with a level of intensity through home visits or phone follow-up. This was a significant variation from the Healthy Homes University II program model.

7.2. Limitations

There were several limitations to the study which may affect the generalizability of the results.

Recruitment Criteria

The Healthy Homes University II project was funded by HUD, and had a recruitment goal of two hundred fifty participants. HUD required that a benchmark of a set number of cases be conducted quarterly. Recruitment criteria included having at least one self-reported ED or inpatient hospitalization, or two unscheduled doctor visits and four SABA fills in the 12 months prior to recruitment. However, if the reporting period was coming to a close and the benchmark wasn't met, then the program would lessen the eligibility requirements for enrollment, and it would be based on control (symptomology) instead of severity or persistence; if the benchmark wasn't met, the program was at risk for a low score that quarter, which would affect future funding opportunities. The attrition table (Chapter 5, Table 5.1) illustrates that only 40 of the 240 participants in Lansing met the ED or hospitalization criteria and 24 months of continuous enrollment in Medicaid, once their claims data was matched with the Medicaid database, and thus were eligible for the cost-benefit study. This small sample could be due to the fact that the program had challenges meeting their recruitment goals, and towards the end of each reporting period, the project enforcement of the required ED or hospitalization requirement to be in the study was not as stringent as the outset. This compromised the strength and integrity of the study, as only one-sixth of the program participants ended up in the cost-benefit study. The representative nature of the sample as compared to the entire HHU II population can be questioned. Also, a question is introduced: did the 210 program participants who did not qualify for the study really have asthma? If they did not, they presumably would have had even lower levels of emergency department visits and inpatient stay, and an even lesser effect on costs.

Effect of recruitment criteria on number of controller and reliever medications filled

Anyone who has experienced a severe asthma event which resulted in emergency department use or an inpatient stay, will as a matter of course leave the hospital with asthma scripts for controller and reliever medications. The fact that those scripts are filled does not indicate whether they were used or not. Also, the experience of emergency department visits and/or hospitalizations may have an effect on proper adherence to the use of the indicated medications. Therefore, the findings may not be generalizable to the general HHU II population, especially those who may not have had a true emergency department visit or inpatient stay prior to enrollment in the program.

Self-Report

Participants were recruited based on meeting self-reported criteria, self-reported ED or inpatient hospitalization, or two unscheduled doctor visits and four SABA fills in the 12 months prior to recruitment. As the self-report was based on recollection, it may or may not have been accurate. There may also have been respondent bias that individuals may report what they believe the program staff wants to hear, and would make them eligible to participate in the program. Future studies should be based on medically verified eligibility for enrollment.

Use of claims data

Administrative claims data only reflects events that have been billed and paid for. If a participant received care outside of the state of Michigan, it would not be reflected in the dataset. Medications which may have been received as samples are not included in the costs and utilization data.

A review of administrative claims served as a proxy for chart reviews. A doctor's confirmation of asthma as documented in a chart review serves as the gold standard for documentation of asthma. Events that were coded as respiratory could have been in effect asthma and may not have been counted.

Continuous enrollment in Medicaid

The study population, by virtue of their 25 months of continuous Medicaid enrollment, continually met a low income threshold for that entire period. The utilization of services of a population going in and out of eligibility for Medicaid may indicate that population at some point may have had access to employer insurance, which may have affected outcomes. The findings, based on those with continuous Medicaid enrollment, thus might not be generalizable to the entire HHU II population.

Price data

The cost of services using 2014 dollars was applied to all utilization data. In doing so, prices may have been overstated by using 2014 dollars. True costs occurred in 2008 through 2011. This is a bias towards showing a larger benefit.

Self-selection into the study

The intervention group self-selected into the HHU II program, and chose to participate in it, contingent on meeting the inclusion criteria. By definition, these individuals may be more proactive than the general populations which was included in the control group. Intervention participants may have been hyper aware of their asthma, which may have accounted for more asthma related outpatient and ED visits than the intervention group, and a greater number of asthma related RX scripts being written and filled.

Regional variation

The intervention region (Lansing) may have had a greater amount of physician training related to asthma management than the control regions (Kalamazoo and Jackson), which may explain the initial differences between the control and intervention groups.

Quantity of the intervention

The quantity of the intervention differed between the participants. All received components of a baseline intervention, with basic services based on identified needs, and a limited number received a custom intervention, which was more extensive. Finally, a few benefited from partner interventions, which were typically more extensive and in addition to the basic and custom services that were provided to all. These varying quantities of intervention were not accounted for in the study.

Emergency department admissions and inpatient admissions

A number of cases (under 10) represented individuals which presented themselves and received services at the emergency room, and then were admitted into the inpatient unit. These cases were counted in both categories, as from a cost perspective there were charges to both types of care.

Selection of control population

Controls were chosen from two comparable Michigan cities which had not received any known healthy homes interventions, Kalamazoo and Jackson, in order to ensure that the control population was not ‘contaminated’ with healthy homes information or messages. Whereas this was done to neutralize bias, it may have introduced bias by choosing different cities with different populations, a different medical community, and varying patterns of utilization at the outset.

Because asthma exacerbation is correlated with time of year, controls were frequency matched by the 25 month timeframe of the intervention group (12 months pre-intervention month, the intervention month, 12 months post-intervention month). To allow for more flexibility in the analysis, this was the extent of matching when selecting controls. In retrospect, matching on demographic information as well may have provided a better control population.

7.3. Policy Implications

7.3.1. From an insurer perspective

The objective of this study was to consider the cost-benefit of a healthy homes intervention project from an insurer/payer perspective. The hypothesis that children with moderate to severe asthma who receive asthma education and environmental interventions in the home would have lower total medical costs related to lowered utilization of outpatient, emergency department, hospitalization, and use of rescue medications due to acute asthma events than children in a matched control group which do not receive any interventions was false. Although there was a decrease in hospitalizations, and an increase in the use of controller medications, there was no significant change in the amount of total medical expenditures between the group which received the intervention, and the control group. A number of limitations have been explored, and thus the finding is not conclusive.

These findings were consistent with other studies which did not show a cost-benefit for the intervention (Table 7.1). Studies which have reported benefit-cost ratios ranging from 5.3-14.0 [60-62] had a strong focus on certified asthma educators, nurses, or respiratory therapists providing patient education, with a level of intensity through home visits or phone follow-up. The model of patient education should be further investigated as a best practice which may justify a business case for paying for the service. It may be that for any given patient population, if asthmatic patients are stratified based on diagnostic criteria and utilization of services, those in the highest risk group may benefit from asthma education and environmental trigger supplies as needed, and it may be cost-effective [24]. This model is being implemented in Michigan by the Asthma

Network of West Michigan, which is receiving fee-for-service payment for case management from Priority Health and four other Medicaid providers; however the reimbursement does not cover the full cost of the program [24].

Health Plans may be most concerned about the relative value of various health care services, and would be most concerned with the costs incurred in producing or arranging for medical care for their subscribers [36]. In that case, a lack of findings in any of the four cost categories of interest make the investment very difficult to justify from this perspective. Health plans are not as concerned about quality of life issues such as return to work, as they are not responsible for disability payments.

Hoppin [24] suggests the following actions from public and private payers wishing to establish comprehensive asthma management programs: 1) establish incentives for providers to appropriately classify patients, monitor drug usage, and refer patients to clinical and in-home education sessions; 2)reimburse providers for asthma education delivered in clinical and home settings; 3) pay for supplies and services shown to improve self-management and reduce exposures to environmental triggers; 4) offer reimbursement mechanisms for the range of non-physician providers of asthma education and environmental services working in both clinical and community settings, including certified asthma educators; and 5) provide or reimburse for case management and outreach staff that complement quality primary care for high risk patients. Another key step is to identify what outcomes and outputs will be measured, and how they will be measured, so that program outcomes and results can be tracked [29].

7.3.2. From other perspectives

Employers expend 2.5 times as much for patients with asthma compared to those without the disease, predominantly on prescription medications [5]. Employers in general have not aligned their health benefits with the recommended best practices for asthma management, however they stand to gain from increased productivity, reduced employee absenteeism, and increased presenteeism. They can promote comprehensive asthma management by securing coverage for asthma management services and supplies; offer asthma education through worksite health promotion programs; offset expensive co-payments; and assess work conditions and exposures to promote safe working environments [24].

Governmental entities such as the EPA note that as health plans pay a major portion of costs spent annually on asthma, they should consider incorporating asthma education and environmental interventions such as HHU II into their disease management approach [29] as access to these interventions remain scarce [24] .

The goal of economic efficiency in public health is to “contribute to the highest attainment of public health... given available resources” [34]. Therefore, opportunities foregone because resources were allocated to a given strategy must also be taken into account. Public health often uses the societal approach, in which all significant costs and health effects associated with everyone affected by the intervention would be included in the analysis, regardless of the payer or benefactor [32], [33] and [36]. This approach would be consistent with the ‘Health in All Places’ (HIAP) public policy approach, which acts on the social and environmental factors that influence health but are out of the control of the health sector [39]. Currently, of the 18% of the U.S. gross domestic product devoted to health care, 99% of those health care expenditures target individual medical care [12]. Very few resources are available to target public health and prevention programs that could benefit the entire population [36]. Pharmaceutical companies invest tens of millions to develop high tech and revenue-generating disease control strategies for asthma. As Krieger begs the question, “who will develop the high-touch strategies (as was attempted in this program through home visiting and home remediation) which do not capture the interest of the pro-profit health care industry?” The annual cost for a year’s supply of inhaled fluticasone propionate (220 ug) is approximately $2200 per year, yet home visit programs are not reimbursed by health care payers [41]. The costs for such programs are up-front, and the benefits, if any, accrue over months or years. The fact that home visit and home remediation benefits accrue over a long period of time does not encourage managed care organizations to pay for services for which they may not benefit from over the long-term.

The Healthy Homes University II as currently structured does not provide good value for the money. Resources should be directed to programs that provide better health outcomes per dollar to maximize health impact. The program should be redesigned to provide better value (lower cost or better impact).

7.4. Suggestions for Future Research

Future studies should be based on medically verified eligibility for enrollment, and be limited to severe cases of asthma in order to have a chance to show any cost-savings. Individuals with severe asthma would presumably have higher utilization rates than those of individuals with controlled asthma, and would have the potential to make the savings worthwhile.

Determining which type of intervention will be most effective for which type of patient is important, and help determine what interventions are effective, as the least resource intensive interventions may be the most cost-effective [35]. This study did find that the intervention increased the use of controller medications, and decreased the number of hospitalizations. It will be important to tease out the effect of the home visiting and education, versus the home remediation itself. Also, the effect of basic or custom remediation could be taken into account in future studies, as well as investigating if the age of housing, rental occupancy status, or caregiver education play a role in the outcome of the study.

Future studies must be designed with the ability to identify controls which are from the same community to address a number of limitations which had been identified. Ideally, this would be in the form of a randomized controlled trial.

It is important that future studies to be able to measure and quantify symptom free days and also other quality of life factors. If these variables are significant enough, they may be able to justify the costs of environmental remediation efforts, especially from an individual perspective.

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