San Diego Healthy Homes Collaborative FY2010-2013

Evaluation Findings Summary Report

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Background

The City of San Diego Environmental Services Department administered a thirty seven (37) month grant from June 1, 2010 to June 30, 2013. The grant funded by the Department of Housing and Urban Development (HUD), Office of Healthy Homes and Lead Hazard Control, called the *San Diego Healthy Homes Collaborative* (SDHHC or Healthy Homes) was intended to address housing conditions that threaten the health of residents, especially young children. Specifically, the grant made it possible to identify environmental and safety hazards in the home and then implement cost effective measures, at no cost to the occupants, to create healthy homes for families and children. The program was available to residents of the City of San Diego including:

- Households that had at least one child less than 17 years of age who was diagnosed with asthma or has asthmatic symptoms
- Households that had a child under the age of five or a pregnant woman.

As part of the SDHHC grant program, the National Latino Research Center (NLRC) at California State University San Marcos conducted the program evaluation. All data collected by the City of San Diego was transferred to the NLRC and converted to a SPSS – statistical package software – file to conduct statistical analyses. Findings are computed by statistically analyzing change between initial assessments (pre-intervention) and follow-up interviews (post-intervention).

The evaluation was intended to assess impact of the intervention and evaluate the cost effectiveness of the SDHHC strategy in addressing health and safety hazards in San Diego's housing stock. A primary focus of the evaluation was to evaluate the level of reduction in asthmatic episodes among children and to evaluate the overall effectiveness of the program's cost benefit achieved through the program's education and renovation activities. Through a multi-tiered and collaborative approach, the City of San Diego successfully fulfilled its grant funded objectives and achieved expected project outcomes. This report summarizes overall evaluation findings.

Quality Control and Assurance

In order to ensure that program staff correctly and accurately implemented the assessment protocols, Quality Control was achieved by field monitoring of project staff and assessment of implementation of major project activities. The principal components associated with data quality are precision, accuracy, representativeness, completeness and comparability. In this project, each component was addressed to assess analytical performance and data quality. Specifically, the quality assurance and data validation was assessed by conducting ongoing field audits of data collection for sampling units, tracking of time to complete intervention in all units, and data validation. Self-assessment, audits and peer reviews provide an overall picture of the conformity with the standards outlined in the quality assurance plan.

Precision and accuracy of data collection procedures was observed through field audits from enrollments and follow-up assessments conducted by field inspectors and health educators. The quality assurance inspector was properly introduced to project participants and the nature of the evaluation was disclosed. The field inspectors followed the required protocol. No violations were observed in the dust allergen composite sampling procedures. Similarly, a visual inspection for mold and excessive moisture was thoroughly performed throughout each room in the sampled residence. Overall precision performance for data collection is considered optimal. In fact, this project has shown that a tailored environmental indoor intervention can effectively reduce asthma symptoms.

Representativeness is a qualitative measure expressing the degree to which the data accurately and precisely represent the conditions intended to be examined. Recruitment for inclusion in the project followed precise criteria established in the quality assurance plan. The demographic characteristics of the participants of the project met all the criteria for inclusion in the project. The project management team has done an excellent job of ensuring that the targeted population is appropriately represented in the project.

The NLRC also conducted ongoing monitoring of SDHHC data collection and management and reviewed forms for accuracy and completeness to ensure they are within approved and established Human Subjects protocols and in compliance with requirements delineated in the approved Quality

Assurance Plan (QA) and Human Subjects Review Board protocols. For data collection and management, the completeness is expressed as the percentage of participants who have successfully completed all components of the project as scheduled in the quality assurance plan. NLRC conducted two Client Case File Audits during throughout the SDHHC grant program period. The audits consisted of evaluating 10% of randomly selected client files to assess data integrity. Data integrity is a critical aspect of the research design which will contribute to the overall quality of the program. The database and case files were consistent in these two audits.

Comparability expresses the confidence with which one data set can be evaluated in relation to another data set. For this project, comparability of data was established through the use of the National Healthy Homes model; other HUD funded Healthy Homes projects, and empirical publications. The Centers for Disease Control and Prevention's (CDC) Task Force on Community Prevention Services recently published reviews and evaluations on asthma education and environmental inventions. Nurmagambetov et al. (2009) found that "the combination of minor to moderate environmental remediation with an educational component provides a good value for the money invested based on improvements in symptom-free days, savings from averted cots of asthma care, and improvement in productivity."

Participant Demographics

In order to qualify for the Healthy Homes program, the unit must either have, at least, one child less than 17 years of age who has been diagnosed with asthma or suffers from asthmatic symptoms or a child under 5 years of age, and have a household income no greater than 80% of the area median income. 370 families (housing units) contacted the SDHHC grant program and 232 households were subsequently determined to be qualified for enrollment in the program. 217 of these units underwent initial inspection and were evaluated for household health and safety issues. Intervention activities began with 186 participating households. 180 households completed the intervention activities during the grant, and 177 households completed the follow-up assessments. These 177 units housed 334 qualifying children including 220 children with asthma or other respiratory illness. Of these 177 units, 140 households had at least one child less than 17 years of age that was diagnosed with asthma or has asthmatic symptoms, and 37 additional housing units have a child under the age of six or a pregnant woman.

A glimpse of health issues such as asthma prevalence and participant demographics illustrate the severity of health disparities present in low income and diverse communities. During the initial visit, results of the asthma assessment indicate that 96.3% of the children who were living in the participating households had been prescribed asthma medication and 84.3% of the children had asthmatic symptoms prior to the intervention.

Table 1: Summary of Demographic Characteristics of Participating Households (N=177) and Qualifying Children Who Were Living in These Households (N=334)

	Description of Analysis			
Indicator(s)	**Participating Household (n=177)**		**Qualifying Children (n=334)**	
Ethnicity/Race	Asian	1.12%	Asian	1.50%
	American Natives	0.00%	American Natives	0.90%
	African American or Blacks	6.21%	African American or Blacks	7.78%
	Pacific Islanders or Hawaiian	0.56%	Pacific Islanders or Hawaiian	1.20%
	White or Caucasian	91.54%	White or Caucasian	86.23%
	Other	0.56%	Other	1.50%
	Unknown	0.00%	Unknown	0.30%
Hispanic/ Non-Hispanic	Hispanic	89.3%	Hispanic	85.63%
	Non-Hispanic	10.7%	Non-Hispanic	14.37%
Sex			Male	51.50%
			Female	48.20%
			Unknown	0.3%
Primary Language Spoken at Home	Spanish as their primary language at home	80.8%		
	English as their primary language at home	19.2%		
Household Annual Income	Less than $10,000	1.12%		
	$10,000-19.999	29.3%		
	$20,000-29,999	32.77%		
	$30,000-39,999	18.08%		
	$40,000-49,999	6.78%		
	$50,000-59,999	3.52%		
	$60,000-79,999	1.12%		
	$80,000 or more	0.56%		
	Refused to answer	1.69%		
Type of Housing Units	Tenants	81.36%		
	Homeowners	18.64%		

Table 1 provides demographic data representing the participating households (n=177) and qualifying children who were living in these participating households (n=334). The majority (91.54%) of study participating households self-identified as White, but those who self-identified as White include Hispanic (96.3% Hispanic and 3.7% Non-Hispanic). Indeed, 80.8% of the study participating families reported that they speak Spanish as their primary language at home. Given bi-/multi-racial

families, children in these households answered quite differently to the race/ethnicity question from the household representative. 86.3% of the qualifying children self-identified as White, and the majority of them were Hispanic. 51.8% of the children in these households were male, and 48.2% were female. More than 60% of the households earn less than $30,000 annually (the majority of participating families had 4-5 individuals living in a household), significantly lower income than the federally defined low-income family level[1]. It is also noticeable that only 18.64% of the study participating families were homeowners compared to 81.36% tenants.

At the time of the initial household interview, 98.8% of the families responded "Yes" to having some kind of medical insurance. The following chart provides the percentage of participating children by type of healthcare coverage:

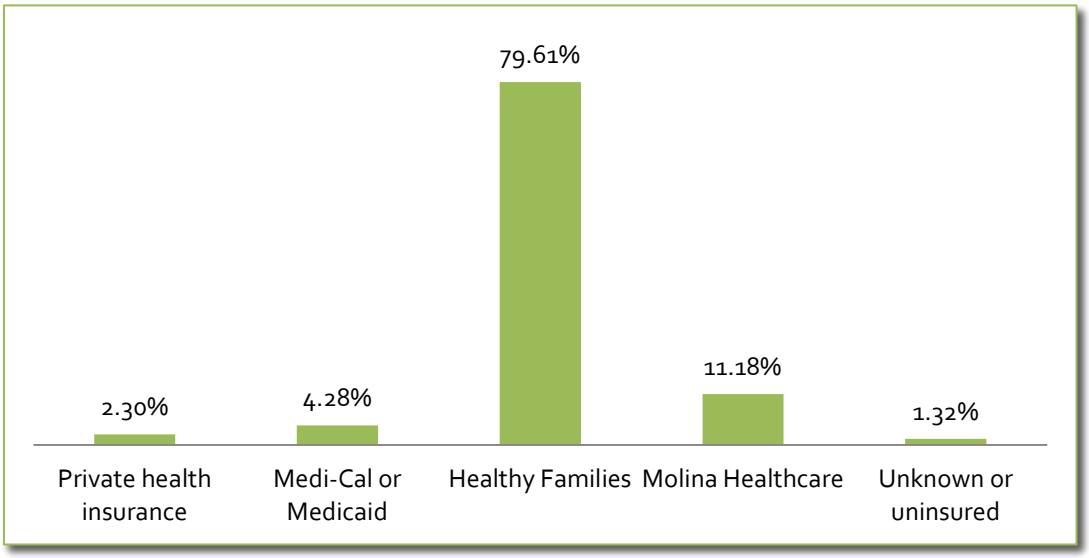

Figure 1: Types of Healthcare Coverage

[1] According to U.S. Department of Education (2013), as of January 24, 2013, the federally defined low-income family level is annual household income of $35.325 for families with 4 individuals living in a household and $41,355 for families with 5 individuals living in a household in 48 contiguous States, D.C. and Outlying Jurisdiction.

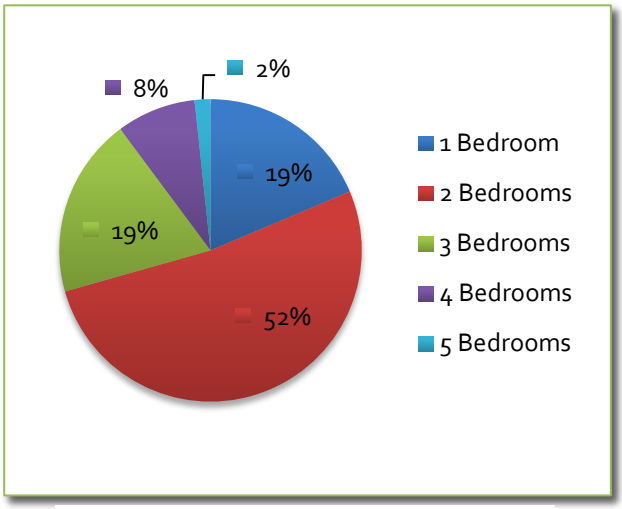

Figure 2: Number of Bedrooms in Unit of Participating Households

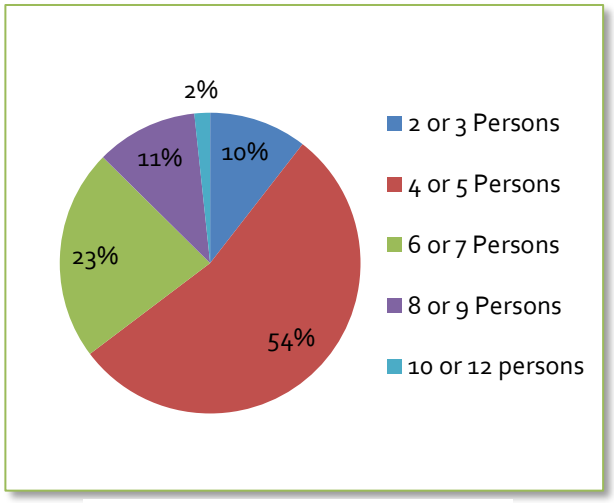

Figure 3: Number of People Living in Participating Households

Only 2.3% of participating households had private health insurance, and 3 families reported that they were not insured or unknown. Most participating children (79.6%) are covered by the California Healthy Families Program which is only available to families with limited income and "provides low cost insurance that provides health, dental, and vision coverage to children who do not have insurance today and do not qualify for no-cost Medi-Cal" (Healthy Families Program, 2013).

As shown in Figure 2 and Figure 3, about half (52%) of the units that received the intervention had only 2 bedrooms, and about 20% of the units had only one bedroom. Indeed more than 90% of the units had less than 3 bedrooms while the average number of people living in these households was 5.25. Specifically, more than half of the households that received the intervention had 4 or 5 individuals living in one household and almost a fourth of the households had 6 or 7 individuals living in one household. This shows that many of the participating households are dealing with crowded living conditions.

Reduction in Asthmatic Episodes

One of the main goals of the evaluation was to determine if the current intervention could reduce the severity of asthma symptoms and the asthmatic episodes for asthmatic children living in those households. To address this goal, an asthma assessment questionnaire was administered at the beginning of the intervention (pre-intervention) and approximately 180 days after the completion

of the intervention (post-intervention). The asthma questionnaire asked 142 parents (households with asthmatic children) to report on their children's (220 total) asthma symptoms experienced within the two weeks previous to administration of the questionnaire.

Parents were asked how often their children had had any asthma symptom during daytime such as coughing, wheezing, or shortness of breath within the two weeks previous to the interviews. Then they were instructed to answer with the following options: 1) Everyday, all the time, 2) Everyday, but not all the time, 3) 3-6 times per week, but not every week, 4) 2 times a week or less and 5) none. As shown in Figure 4, at the pre-intervention, only 32 children did not show any asthma symptoms during the day while the majority of the children (188) had asthma symptoms. In turn, at the post-intervention interview, parents reported that 149 children did not have any asthma symptom, and there were only 71 children who had any asthma symptom during daytime (most of them only had any asthma symptom 2 times per week and no one reported everyday, all the time).

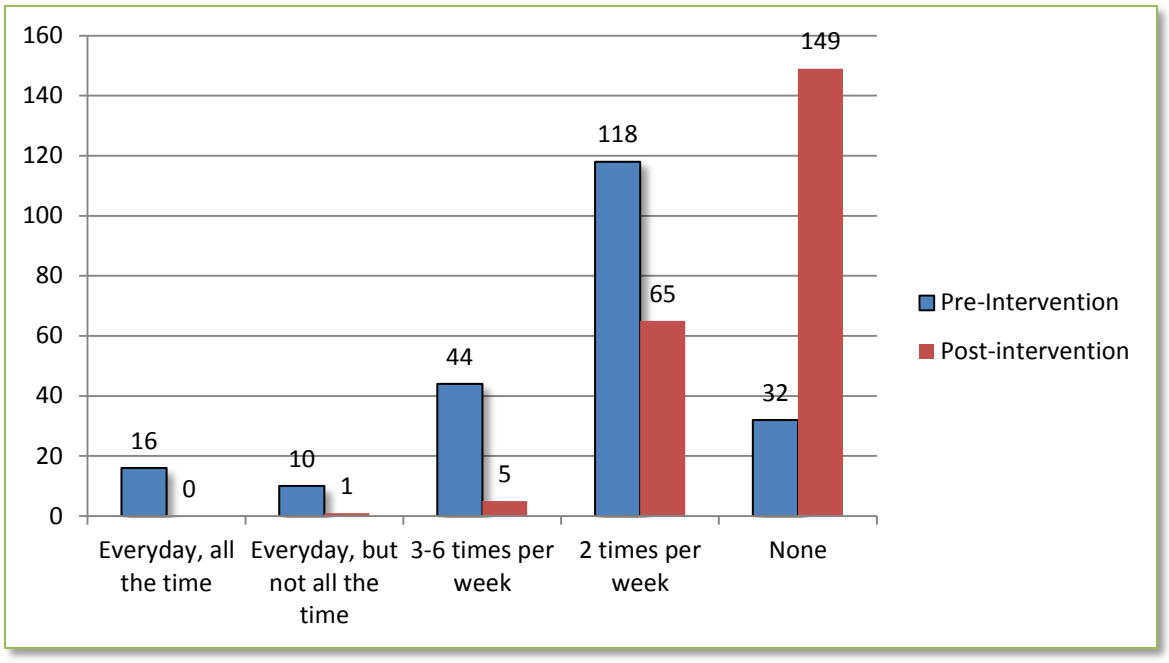

Figure 4: Daytime Asthma Symptom Pre- and Post-Intervention

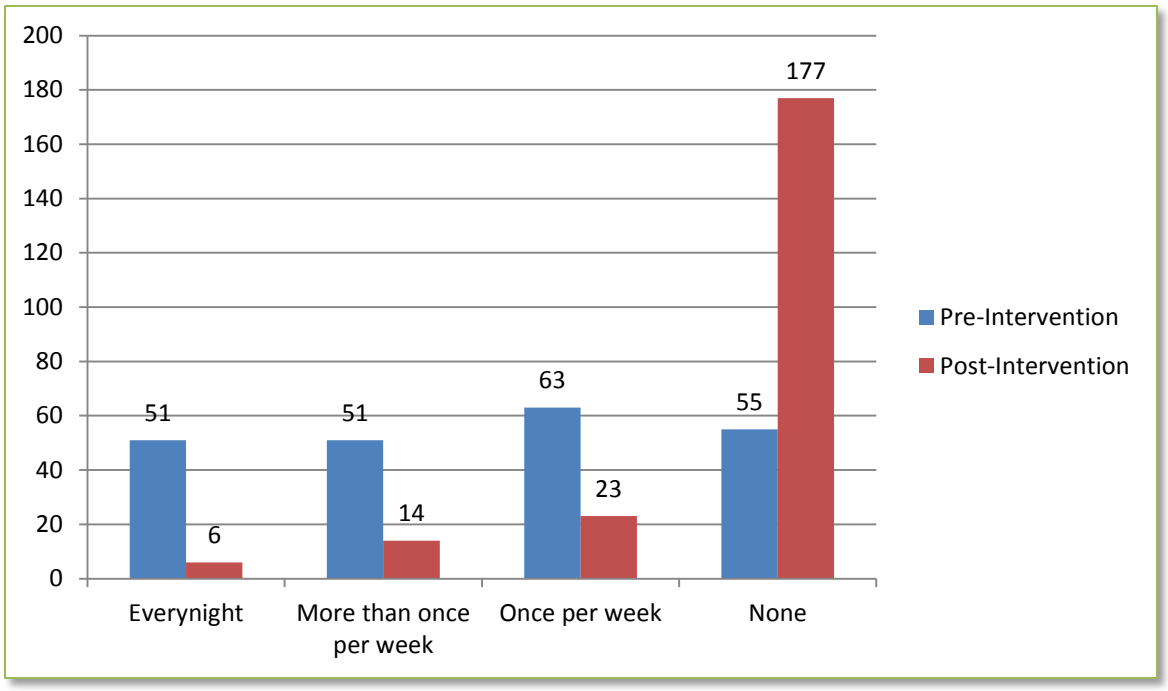

Figure 5: Nighttime Asthma Symptom Pre- and Post-Intervention Comparison

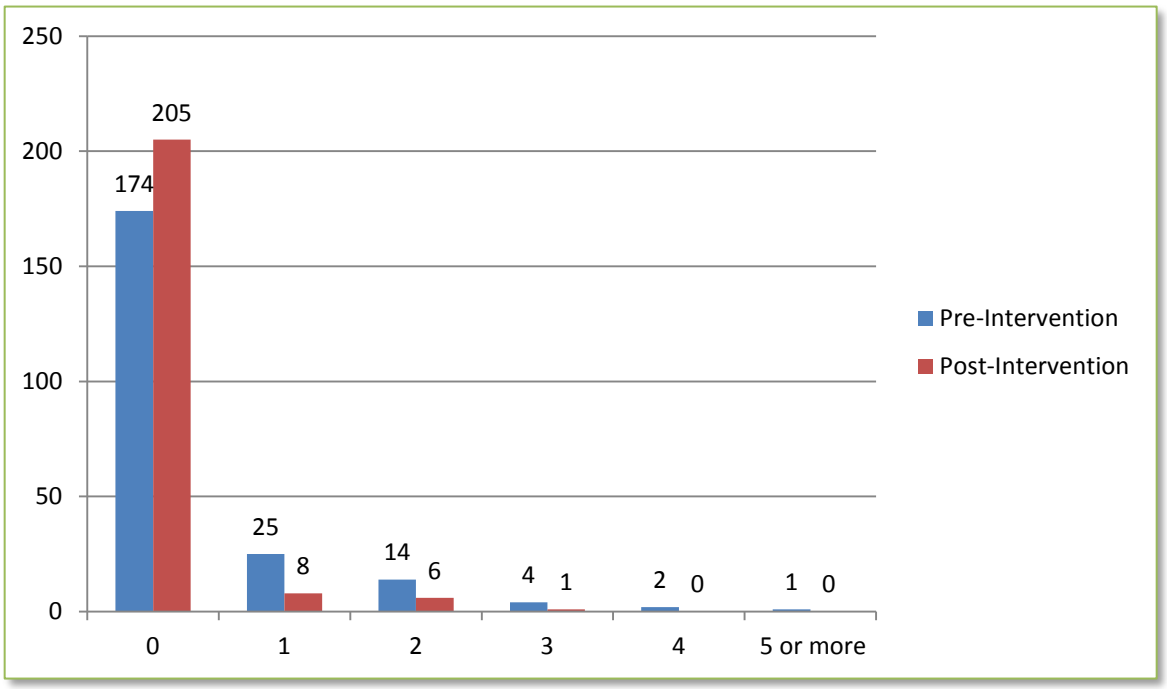

Figure 6: Urgent care (ED) Visit Past 6 Months Pre- and Post-Intervention Comparison

Furthermore, Figure 5, Figure 6 and Figure 7 show similar results for nighttime asthma symptom, urgent care/emergency department (ED) visit past 6 months and quick relief use pre- and post-intervention comparisons. It is evident that, after completing the program, many households

reported that their children had less asthma symptoms during the night, they did not have to visit urgent care/emergency department (ED) as many times as before the intervention and they did not use quick relief as often as before the intervention. At the pre-intervention interview, parents reported that 75.0% of their children had nighttime asthmatic symptoms. However, after the intervention, 80.5% of participating children did not suffer from any nighttime asthma symptom. 46 children needed to visit urgent care/emergency department (ED) at least once in the past 6 months at the pre-intervention, but, after the intervention, parents reported that only 15 children needed to visit urgent care/emergency department (ED), at least, once in the past 6 months. Similarly, 76.8% of the participating children needed to use quick relief, but, after the intervention, parents reported that 75.0% of their children did not need to use quick relief.

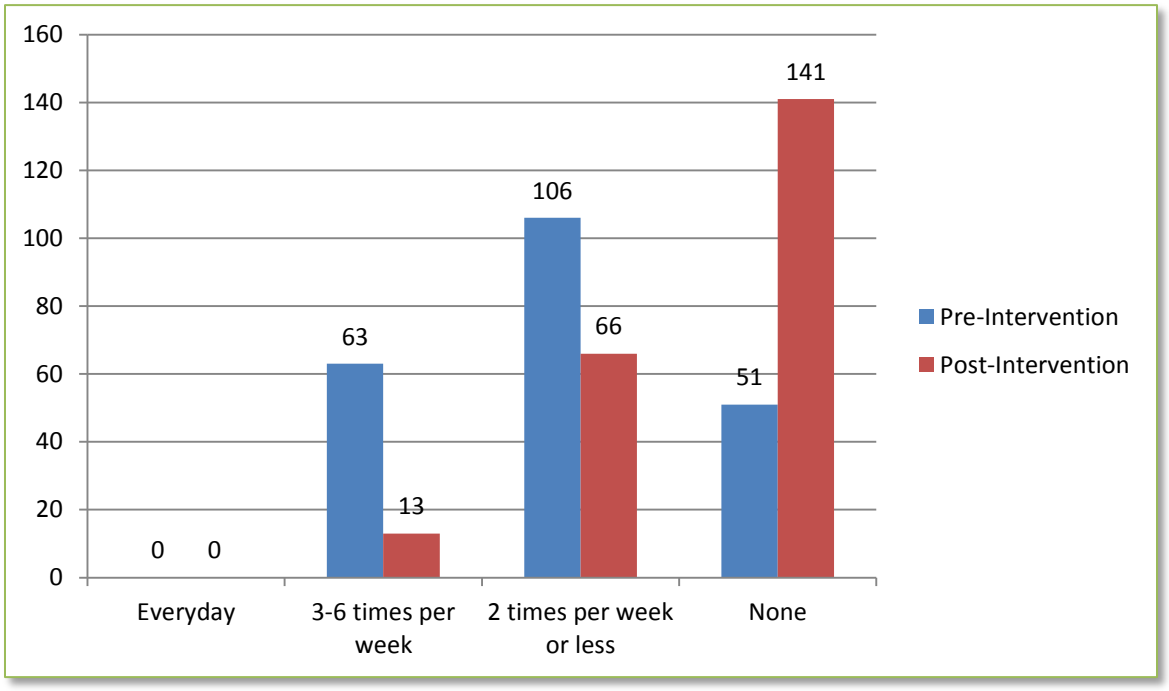

Figure 7: Use of Quick Relief Pre- and Post-Intervention Comparison

These results were further validated by statistical tests, using an IBM SPSS – statistical package software. Answer options were converted to numeric values and used as a scale (ranging from zero to 4, or zero to 3, depending on the questions) to compare means. Paired sample t-tests were used to compare the pre and post means, and results showed a statistically significant reduction in daytime asthmatic symptoms ($p < .000$)[2], nighttime asthma symptoms ($p < .000$)[3], nighttime

[2] Indicates statistically significant reduction (p<.05) from pre-intervention
[3] Indicates statistically significant reduction (p<.05) from pre-intervention

urgent care/emergency department (ED) visit ($p < .000$)[4] and use of quick relief ($p < .000$)[5] (please see Appendix A-1, A-2, A-3, A-4, A-5 and A-6). As mentioned earlier, 188 children had asthma or asthmatic symptoms during daytime prior to the intervention. After 180 days, only 71 children suffered from asthma or asthmatic symptoms during daytime within the two weeks previous to the post-intervention assessment. This reduction was statistically significant, implying that this reduction did *not* occur by chance; such reductions were due to the intervention. The decrease in asthmatic symptoms experienced during nighttime and urgent care/emergency department (ED) visits were also statistically significant. We can also conclude that, after the intervention, there was a statistically significant reduction in the use of quick relief.

Sustainability

One of the primary considerations when investing in the establishment of a Healthy Homes program is the issue of long-term impact and sustainability. Specifically, the question posed is whether or not a Healthy Homes intervention will generate meaningful and sustainable changes in household environments, which will have significant impact on family health beyond the intervention.

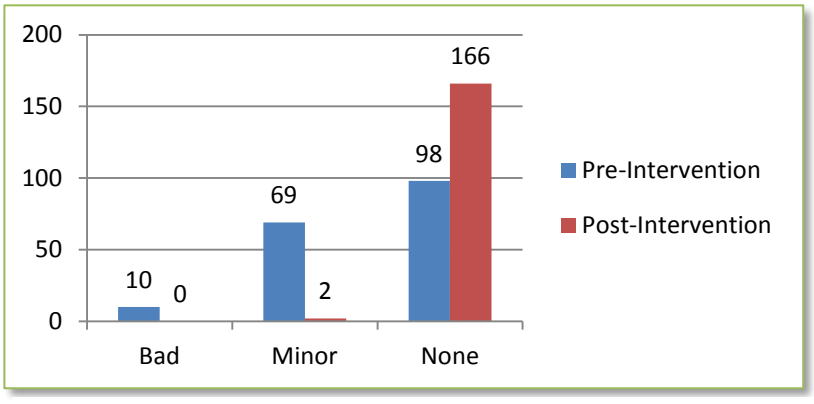

Figure 8: Home Environment Pre- and Post-Intervention Comparison (Rodent)

A total of 180 households received some type of renovation, ranging from improving safety in the home to installing smoke alarms, completing weatherization and/or removing mold infestation. Moreover, as part of the program intervention to ensure residents sustain a healthy living environment, educational/informational sessions aimed at teaching residents how to assess, create and maintain a healthy home was provided to each household. When mold allergens were found in the home, the intervention team worked to remove

[4] Indicates statistically significant reduction ($p<.05$) from pre-intervention
[5] Indicates statistically significant reduction ($p<.05$) from pre-intervention

the mold and taught residents how to maintain a mold free home environment. Residents were also taught how to clean their home with safer cleaning agents that are less likely to cause asthma episodes. Thus, significantly increasing family awareness and education thereby helping families to reduce and/or eliminate asthma triggers in the home.

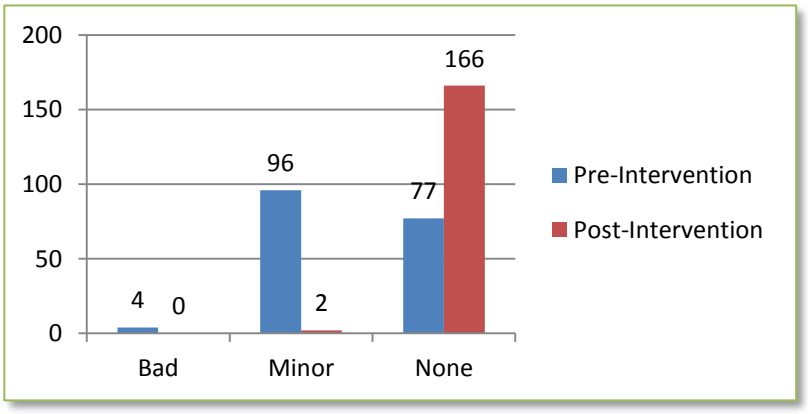

Figure 9: Home Environment Pre- and Post-Intervention Comparison (Mold)

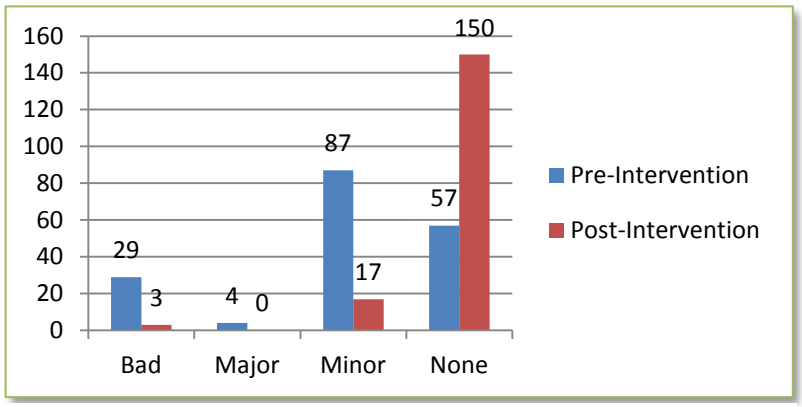

Figure 10: Home Environment Pre- and Post-Intervention Comparison (Cockroach)

For 177 housing units, a household interview and visual inspection were conducted in a pre- and post-test design. The initial household interviews and inspections were used to determine a portion of home health and safety concerns to be addressed for education and intervention methods to be provided for each household. Approximately six months after the renovation activities, similar interviews and assessments were conducted in each household to evaluate if sustainable changes have been made. The household interviews document the self-reported household problems, and the self-reported or identified issues were also visually assessed and documented by qualified inspectors.

The outcome of improved household environments clearly presents health benefits for residents. As shown in Figure 7, Figure 8 and Figure 9, there was a significant decrease in all home environment problems field inspectors identified. The reduction in asthma triggers such as mold, rodent and cockroach infestation demonstrates an increase in awareness as residents are better

educated on how to clean up and keep the house clean in order to reduce/eliminate residents' asthma and other respiratory issues. Mold was a visible problem at the pre-intervention interview among 56.5% of the households, but the percentage of households with mold issue was reduced to only 1.2% after the intervention. Similarly, the inspectors reported before the pre-intervention that 44.6% of the participating households were experiencing some sort of rodent issues, but it was drastically reduced to 1.2% as well. Evidence of cockroach infestation was found in 120 households (67.8%) at the pre-intervention assessment. After the intervention, there was a drastic reduction, and the evidence was found only in 20 households (11.3%).

Figure 11: Pre- and Post-Intervention Example

Improvements were statistically analyzed after converting the degree of 1) mold, 2) rodent and 3) cockroach problems into scales[6]. There were statistically significant improvements (see Appendix A-3 and A-4) in terms of the degree of mold, rodents and cockroaches in residents' kitchen or kitchen/dining room. After the intervention, the degree of mold problem decreased in such a way that only 1.2% of households still have minor problem in the kitchen as compared to 56.5% of households had problem in kitchen at the initial inspection[7]. The improvement for rodent problem was very similar. At the post-intervention inspection, inspectors found only minor rodent problems in households (1.2%)[8]. Drastic improvement was also seen for cockroach problem in these households. 77.8% of households had some sort of cockroach problem while, at the post-intervention inspection, only 20 households (11.9%) still had cockroach problem[9]. Overall, the intervention successfully reduced home environment issues such as mold, rodent and cockroach in

[6] Answer options were converted to numeric values for statistical analysis purpose: Mold (Bad = 2) (Minor =1) (None = 0), Rodent (Bad = 2) (Minor = 1) (None = 0) and Cockroach (Bad = 3) (Major = 2) (Minor = 1) (None = 0)
[7] The reduction in mold was statistically significant (p=0.00). Please see Appendix A-7 for more details.
[8] The reduction in rodent was statistically significant (p=0.00). Please see Appendix A-7 for more details.
[9] The reduction in cockroach was statistically significant (p=0.00). Please see Appendix A-7 for more details.

participating households, which are potential asthma triggers and may have impacted the health status of children and adults. Unfortunately, sustainability of such meaningful changes are still unknown because, after the post-intervention assessment (follow-up interviews), no further assessment was conducted. If funding becomes available, a longitudinal study is recommended to evaluate the sustainability of environmental changes at participant households and its impact on the residents' health.

Cockroach and House Dust Mite Allergens

During the pre and post data collection sessions held at each home, program inspectors collected dust samples in addition to the standard visual inspection. Research by Huss et al. (2001) has shown that exposure to cockroach and dust mite allergens are a major risk factor for asthma. In fact, several research studies such as one conducted by Cohn et al. (2006) have found that levels of cockroach and dust mite allergens in the home is one of the best predictors of allergic sensitization and asthma morbidity. For this project, during the pre-intervention assessment, certified inspectors used a vacuum cleaner to collect household allergens; cockroach allergen (Bla g 1), mite allergen group 1 (Der p 1) and mite allergen group 2 (Der p 2) were collected and analyzed by Forensic Analytical Laboratories Inc. Results showed that, at the pre-intervention inspection, the average presence of allergens collected was:

Bla g 1:	38.59 U/ml with a range of 0.00 U/ml [10] - 2600.00 U/ml
Der p 1:	1.33 ug/ml with a range of 0.00 ug/ml [11] – 62.00 ug/ml
Der p 2:	0.75 ug/ml with a range of 0.00 ug/ml [12] – 12.00 ug/ml

According to Cohn et al. (2006), Bla g 1 concentrations that exceed 2.0 U/ml represent a level significantly associated with allergic sensitization and asthma morbidity. Results showed that about 12.0% of households had a detectable amount of Bla g 1 and were at levels that exceeded 2.0 U/ml. 44.7% of households had a detectable amount of Der p 1, and 60.0% of households had a detectable amount of Der p 2. These results show that an alarming amount of households in this project have high levels of cockroach and/or dust mite allergens.

[10] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount
[11] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount
[12] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount

The pre-intervention results were compared with post-intervention results in order to determine if the implemented intervention had any impact on cockroach allergen, mite allergen group 1 and mite allergen group 2. For the post-intervention assessment, the inspectors also used a vacuum cleaner to collect dust samples as they did at the pre-intervention assessment. Results showed that, during the post-test, the average presence of allergens collected was:

Bla g 1:	0.96 U/ml with a range of 0.00 U/ ml [13] - 110.00 U/ ml
Der p 1:	0.74 ug/ml with a range of 0.00 ug/ml [14] – 22.00 ug/ml
Der p 2:	0.31 ug/ml with a range of 0.00 ug/ml [15] – 6.30 ug/ml

These results showed a drastic improvement in levels of allergens present in the home. Considering the fact that Bla g 1 concentration that exceeds 2.0 U/ml represents a harmful level, the average level of cockroach allergen decreased to the level lower than 2.0 U/ml. Results showed that about 5% of households had a detectable amount of Bla g 1 and only three households (2.1%) were still at levels that exceeded 2.0 U/ml. 26.4% of households had a detectable amount Der p 1, and 38.2% of households had a detectable amount of Der p 2. Overall, the cockroach allergen, mite allergen group 1 and mite allergen group 2 levels for most household were decreased. Although, for the homes that had severe cockroach infestation issues, their Bla g 1 levels decreased, these results showed that households continued to be at levels that exceeded the critical level of 2.0 U/ml.

The limitation of this intervention is that often residents cleaned their homes immediately before the arrival of inspectors, thus decreasing the probability of collecting enough dust samples to properly analyze to detect significant levels of cockroach and dust mite allergens. Indeed, our statistical analyses show that the reduction in Bla g 1 and Der p 1 was not statistically significant[16] whereas the reduction in Der p 2 was statistically significant[17] (please see Appendices A-5 and A-6 for more details). Post-interventions levels of Bla g 1 showed a considerable decrease as compared to average pre-intervention levels (38.59 U/ml vs. 0.96 U/ml); however, this reduction was unfortunately not proved by our statistical analysis. At the pre-intervention inspection, already 132 out of 150 total cases were below the detective amount/level (meaning that we only had 18 analyzable cases to begin with), and it was increased to 137 cases at the post-intervention

[13] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount
[14] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount
[15] Dust sample was not collected by inspectors because floor was clear, or it was below the detectable amount
[16] The reduction in Bla g 1 was not statistically significant ($p=0.051$). The reduction in Der p 1 was not statistically significant ($p=0.283$).
[17] The reduction in Der p 2 was statistically significant at $p < 0.05$

inspection. Similar pattern was found for Der p 1, and unfortunately not enough data is available to evaluate the effectiveness of this element of the intervention. It is very likely that many participants cleaned their homes before inspectors arrived so inspectors could not collect enough dust samples for a proper analysis.

Cost-effectiveness of Intervention

Evidence for the health benefit of this intervention program is typically observed by the significant reduction in frequency and severity of asthma symptoms and reduced direct (costs of medical treatments, etc.) and indirect (loss of work, missed school time due to illness, etc.) health care costs. However, as this project focused on participant's home environment as an important factor which has a significant impact on residing adults and children's health, the program offered home renovation, clean up, weatherization, education materials, etc. that would improve their home environment and thus the health of the residents. To estimate the return on investment of this Healthy Homes program, we have developed a more inclusive and extensive cost-benefit analysis model, which consists of health and weatherization (home environment improvement/energy saving) elements, to calculate realistic expectations for the potential impact of the Healthy Homes program in San Diego based on actual costs.

Many existing Healthy Homes program and other similar programs usually employ the medical approach to improve program participants' health. It is also important to consider environmental factors which have a great impact on residents' health; therefore, this program invested on a variety of services, not limited to health insurance, education, etc. but also home renovation, energy saving and weatherization. Such a broad and comprehensive approach is more costly compared to a traditional individual-level medical approach which focuses heavily on individual-level factors and savings; however, in this cost-benefit analysis, we are estimating the return on investment, including 1) individual/family level benefits, 2) program sponsor/government agency level savings, and 3) more indirect communal and societal level impacts.

In order to conduct a proper cost-benefit analysis, one needs to calculate the total intervention program cost and benefit in monetary value. The total intervention program cost includes expenses such as all services provided to participants and program operational costs. As shown in Table 2, the

total SDHHC program intervention cost per year was $247,818.95 ($1,400.11 per household and $1,126.44 per child).

Table 2: San Diego Healthy Homes Collaborative Intervention Costs (three years total)

Description	Total
Weatherization and Energy Efficiency	$159,558.00
General Construction Health and Safety	$90,072.00
Renovations	$112,986.88
Outreach, Enrollment, Education, & Retention (American Lung Association)	$135,814.00
Laboratory Services (Allergen, Lead and Asbestos)	$18,785.00
Sub Total	$517,216.00
Intervention Operational Cost (Labor/Fringe/Indirect)	$226,241.00
Total Cost (Three Year)	$743,456.86
Total Cost per Year	$247,818.95*
Note: Itemized expenses (sum of the reported actual cost to each targeted home) as of 03/31/2012 (220 participated children and 177 participated households) *Cost per household is $1400.11, and cost per child is $1,126.44	

Program costs per participant per year estimated in other studies typically range from $231.00 to $14,858.00 (Nurmagambetov et al., 2011). Hence, considering the multicomponent intervention approach that the SDHHC program employed, the intervention cost per child in this program was relatively low ($1,126.44).

Unlike calculating the total intervention program cost, estimating costs of asthma at individual as well as societal levels and calculating true program benefits is a very complex task as many other studies have reported. Previous studies have hardly determined "definite" estimates, and previous studies have suggested the estimated cost of asthma with a relatively wide range (Nurmagambetov et al., 2011). Therefore, we have reviewed other studies and program reports to identify potential benefits. It is crucial to identify and estimate all potential benefits and savings from the SDHHC program including direct and indirect costs and benefits to better understand overall intervention impact.

As shown in Table 3, there are various benefits from the SDHHC program at different levels. We have categorized potential benefits into groups and analyzed them at different levels such as individual, government (human services/program sponsors) and communal levels. First, decrease in

medical and healthcare cost to families, government (MediCal, Medicare, etc.) and private insurance/healthcare providers is the most obvious and estimative benefit at all three levels. As most participants do not have private insurance, the reduction in asthmatic symptom, especially among children of lower-income families, means a drastic saving in low-income patients' out-of-pocket medical expense and public assistance, such as MediCal, Medicare and other public assistance, specific to lower-income families whose children usually experience higher asthma rate.

Table 3: Identifying and Estimating Healthy Homes Intervention Benefits

	Individual	Human Services and Program Sponsors (Government)	Communal or Societal
Medical/Health	Decrease in medical costs - Out-of-pocket ER visit - Out-of-pocket doctor visit - Out-of-pocket hospitalization - Out-of-pocket prescriptions or medications (inhaler)	Decrease in expenses of public assistance and other subsidies such as MediCal and MediCare	Decrease in insurance companies expenditure covering medical costs of the insured (most program participants do not have private insurance)
Income	Increase in net earnings - Less work absence*	Increase in tax revenues*	
School & Work absenteeism	Decrease in childcare expenditure*	Opportunity social costs of lowering absenteeism and work loss (estimated unemployment, welfare, etc.)*	More funding to public schools due to less absenteeism*
Property	Decrease in property maintenance expenditure for house owners*	Decrease in expense for City of SD/code enforcement*	Increase in community value and thus school funding*
*Green highlighted items are potential benefits which was not calculable or estimable in this report.			

Moreover, parents usually benefit from reduction in their children's asthma symptoms because they miss less days/hours at work (increase in net earnings) and/or need less childcare. Parents' less work absenteeism also can imply a potential increase in tax revenue for government agencies and less expenditure in unemployment, safety-net programs and other governmental subsidies, especially for parent(s) whose children suffer from severe asthma symptoms and who have to miss work extensively and possibly lose their work. Indeed, "in 2007, asthma was responsible for an estimated 1.2 million missed days of work in California, [and] [l]ow income Californians miss more days of work than their more affluent counterparts" (Wolstein, Meng and Babey, 2010). Centers for Disease Control and Prevention (2011) estimated that "[m]ore than half (59%) of children and one-

third (33%) of adults who had an asthma attack missed school or work because of asthma in 2008. On average, in 2008 children missed 4 days of school and adults missed 5 days of work because of asthma." Furthermore and more specific to California, "…California children with asthma missed nearly 1.6 million days of school because of asthma, [and] low-income children with current asthma missed more than twice as many days of school as those with higher income" (Wolstein, Meng and Babey, 2010). Asthmatic children's less school absenteeism can further reduce particularly low-income household's childcare expenditure and can thus provide more funding to public schools, especially in lower-income area. It is extremely difficult to identify and describe this type of benefits in actual dollar values, but it is worthwhile to discuss for future projects.

All benefits related to weatherization and home environment intervention are very difficult to estimate at this time even though program participants (and home/apartment owners) benefited from home renovation/safety, weatherization, energy saving, clean-up, mold removal and other intervention services to a great extent. Some of these benefits are too indirect to estimate, yet saving in utility, reducing home maintenance expense, increase in community value, etc. are important to mention. Even though we are unable to calculate the exact dollar value saved, it is likely that the intervention has enhanced property value, extended lifetime of dwelling, created more employment (for contractors and other partners), etc. which are all significant benefits.

Table 4: Asthma Related Medical Charges Adverted by the Intervention (Pre and Post Comparison)

Type of Charges	Estimated Charges ($)	Pre-Intervention	Post-Intervention
Emergency Department (ED) Per Visit	$ 922.00[18]	$163,083.36 (0.804 times/year)	$67,342.88 (0.332 times/year)
Hospitalization Per Stay	$9,100.00[19]	$500,500.00 (0.25 times/year)	$140,140.00 (0.07 times/year)
Medication Per Year	$154.00[20]	$33,880.00	$ -
Total		$697,463.36	$207,482.88
Total Per Child		$3,170.29	$943.10
		$2,227.19 (the annual saving per child)	

The potential medical costs adverted by the intervention are shown in Table 4 above. The actual medical cost that participating households spent before the intervention is not available in our data (or unknown by the households because some charges were covered by private insurance,

[18] Machlin and Chowdhury's (2011). Other studies such as Krieger at al. (2006) reported ($116-496)
[19] Please see the Table 1 on "Statistical Brief #58: Hospital Stays Related to Asthma for Children, 2006" by Strangers, Merrill and Steiner (2008)
[20] Please see Karaca-Mandic et al. (2012)

Medicare, Medicaid, etc.); however, as shown in Table 4, other studies report actual and estimated medical costs, which are applicable and will be used in this analysis. The average asthma related emergency department (ED) visit per year at the pre-intervention interview was 0.804 among participating children, and it was reduced to 0.332 times per year after the intervention. As Machlin and Chowdhury (2011) estimate, the average charge for an ED visit is $922 ($242 patient out of pocket and $680 insurance), while other studies reported estimates of an ED visit with a very wide range. Based on Machlin and Chowdhury's (2011) estimate, the total charges for ED visit among 220 participating children per year before the intervention was $163,083.36 (or $922 x 220 children x 0.804 average annual ED visit per child), and it was reduced to $67,342.88 (or $922 x 220 children x 0.332 average annual ED visit) after the intervention. Hospitalization is usually more costly to the households with asthmatic children, insurance companies, medical providers, etc., so the estimated benefits are even more significant. According to Strangers, Merrill and Steiner (2008), the reported total charges for child hospitalization due to asthma as a primary diagnosis per stay was $9,100. The average frequency of hospitalization among SDHHC participating children was 0.25 times per year before the intervention, so the annual asthma related hospitalization cost among them was $500,500.00, which was decreased to $140,140.00 after the intervention. Furthermore, families with asthmatic children annually spend $154.00 per child for asthma related medication such as quick relief (Karaca-Mandic et al., 2012). The estimated total cost of medication before the intervention for the 220 participants was $33,880.00.

So far, we have calculated the estimated saving in medical charges such as asthma related ED visit, hospitalization and medication. Before the intervention, the total estimated cost to families, private insurance companies and government for these medical and healthcare charges was $697,463.36 (or $3,170.29 per child). After the intervention, the estimate was reduced to $207,482.88 (or $943.10 per child). The difference (saving) is $2,271.19 per child, which is the potential dollar value that the intervention has successfully saved. This estimated saving is less than the program cost per child ($1,126.44) as discussed earlier, and the program cost-benefit ratio was 1.00:2.02 (this is without other potential benefits discussed earlier).

This cost-benefit analysis presents a new model to calculate intervention cost-benefit to be further elaborated in future interventions. As discussed earlier and shown in Table 3, it was not possible to include values for all direct as well as indirect benefits. However, it is crucial to take these potential

benefits into consideration when evaluating the SDHHC program and planning future programs. Additionally we will see more long-term and/or more invisible benefits, which might not have been detected in this intervention. Participants are benefitting from the program in many different ways, and some of these benefits reach beyond the participating households benefitting the larger community, government program sponsors, human services and other private business groups. Therefore, additional research is needed to better understand these benefits across agencies and organizations. Yet, even without those potential benefits, results show that the SDHHC program is a very cost-effective program that reduced unnecessary expenses that families with asthmatic children, government and private business groups usually incur.

Figure 12: Renovation Example Pre-and Post-Intervention

Conclusions

Overall, results show that the SDHHC intervention is indeed cost-effective, and it drastically improved household environments thereby improving children's health. Additionally, this project met one of the four vital components of effective asthma management practices outlined by the National Institute of Health (2003) such as environmental control measures to avoid or eliminate asthma triggers that contribute to asthma onset and severity. In sum, the project successfully achieved the outcome of teaching participants how to effectively manage asthma and maintain a healthy home environment. Clearly, the project was very important to the community as it provided significant services and opportunities for family empowerment and lower-income community empowerment to combat asthma by reducing key environmental triggers inside the home. This project was a stepping stone in helping, particularly lower-income and Spanish-speaking households become knowledgeable of the connection between health and housing, and more specifically about the environmental triggers related to asthma management.

Lessons Learned and Recommendation

Many lessons were learned while implementing this intervention. One lesson learned is that culturally and linguistically responsive education can serve as a method to eliminate many of the linguistic and cultural barriers participants face. Spanish-speaking families comprised 80.8% of program participants (compared to 19.2% English-speaking participants). As many research studies suggest, the best interventions are ones that include culturally and linguistically appropriate instruments and studies have shown that the effectiveness of home-based multi-trigger and multi-component environmental interventions is interrelated to whether the design was tailored to the individual (Cooper, Hill and Powe, 2002). In addressing such issues, the program utilized bilingual health educators and inspectors who spoke Spanish fluently and were culturally sensitive to the needs of Latino families involved in the program.

One area to improve is to identify strategies to deliver scientific and technical information to families with limited educational attainment. Although Spanish educational materials were provided in Spanish, the written assessment reports for each household were prepared in English only. Spanish speaking program staff reviewed these reports with Spanish speaking households and translators were utilized for other non-English speaking households, but non-English speakers have limited access to the report's information beyond the presentation. Modification of the report could greatly increase family's access to information and translation into Spanish will also enhance the program's cultural and linguistic appropriateness.

Discussions

There are numerous environmental injustices in low-income communities (National Latino Research Center, 2012). At the forefront is the lack of resources and knowledge on healthy homes and its relation to health. Over the past decade, the prevalence of asthma-related health disparities among individuals living in substandard conditions has continued to rise despite better understanding of the effects of exposure to toxins such as mold, cockroach allergens, hazardous cleaning agents, and indoor air quality. Exposure to such toxins is documented as a significant risk factor for asthma and other health issues. The implementation of this healthy homes project has been well accepted and welcomed by the community. An area that could be improved is education

of environmental factors in the neighborhood. It would be relatively simple to incorporate additional education and data collection to better understand the environment in the local neighborhood.

As a result of this project, several community based organizations have gained knowledge about relevant issues and have been able to create community empowerment. Currently, community organizations throughout the county are pursuing innovative organizing and advocacy strategies for corrective and preventive action through access to hazard assessment tools and training in their use, technical assistance, strategy advice, and mechanisms for peer to peer support. Simultaneously, the project results have found significant correlations between indoor environmental health hazards in substandard housing and health. This project has been able to compile research finds and best intervention strategies to address environmental health hazards found in the homes. It is clear that this project has designed in-depth asthma education materials that have increased community awareness about asthma control and management, asthma symptoms, environmental health hazards, and use of asthma medication.

One of the primary reasons that this project was well received by the community is because the most effective community partners were fully supportive and engaged. Project staff was easily able to establish rapport with the community given the level of involvement of all partners. As environmental health research is receiving more attention, researchers, advocates, health professionals, policymakers, funders, and others are asking more questions regarding the connections between substandard housing, indoor environmental health hazards, and health impacts. This project has made significant progress towards adding fruitful results and knowledge to the growing body of literature that is contributing to increased understanding of the relationship between substandard housing and health while using a cost-effective approach.

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Appendices

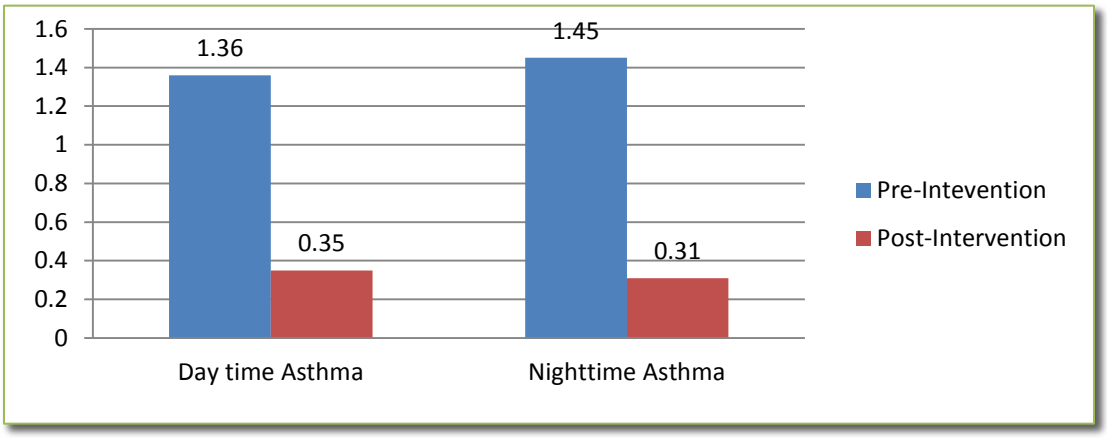
Appendix A: Asthma Symptom, Home Environment and Cockroach Allergen Pre- and Post-Intervention Comparison Tables and Charts.

Appendix A-1: Daytime and Nighttime Asthma Symptom Pre- and Post-Intervention Comparison Table[21]

	Pre-intervention		Post-intervention		
Daytime Asthma Symptom (N=220)	Everyday, all the time	16 (7.3%)	Everyday, all the time	0 (0.0%)	t=12.788 df=219 p=.000*
	Everyday, but not all the time	10 (4.5%)	Everyday, but not all the time	1 (0.5%)	
	3-6 times/week	44 (20.0%)	3-6 times/week	5 (2.3%)	
	2 times/week	118 (53.6%)	2 times/week	65 (29.5%)	
	None	32 (14.5%)	None	149 (67.7%)	
	System missing	0 (0.0%)	System missing	0 (0.0%)	
Nighttime Asthma Symptom (N=220)	Every night	51 (23.2%)	Every night	6 (2.7%)	t=13.450 df=219 p=.000*
	Once/week +	51 (23.2%)	Once/week +	14 (6.4%)	
	Once/week	63 (28.6%)	Once/week	23 (10.5%)	
	None	55 (25.0%)	None	177 (80.5%)	
	System missing	0 (0.0%)	System missing	0 (0.0%)	

* Indicates statistically significant reduction (p<.05) from pre-intervention

Appendix A-2: Asthma Symptom Pre- and Post-Intervention Mean Score Comparison Chart



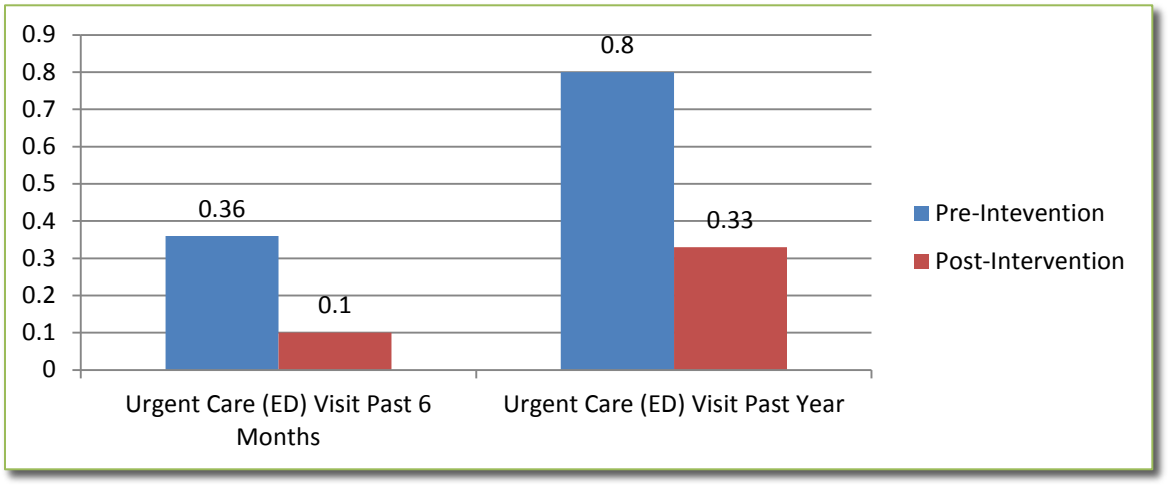
[21] Answer options were converted to numeric values for statistical analysis purpose: Daytime Asthma Symptom (Everyday all the time = 4) (Everyday but all the time = 3) (3-6 times per week = 2) (2 times per week =1) (None = 0), and Nighttime Asthma Symptom (Every night = 3) (More than once a week = 2) (Once a week = 1) (None = 0)

Appendix A-3: Urgent Care (ED) Visit Past 6 Months and Past Year Pre- and Post-Intervention Comparison Table

	Pre-intervention		Post-intervention		
Urgent Care (ED) Visit Past 6 Month (N=220)	0	174 (79.1%)	0	205 (93.2%)	t=4.239 df=219 p=.000*
	1	25 (11.4%)	1	8 (3.6%)	
	2	14 (6.4%)	2	6 (2.7%)	
	3	4 (1.8%)	3	1 (0.5%)	
	4	2 (0.9%)	4	2 (0.9%)	
	5	0 (0.0%)	5	0 (0.0%)	
	6 or more	1 (0.5%)	6 or more	0 (0.0%)	
	System missing	0 (0.0%)	System missing	0 (0.0%)	
Urgent Care (ED) Visit Past Year (N=220)	0	147 (66.8%)	0	182 (82.7%)	t=4.742 df=219 p=.000*
	1	32 (14.5%)	1	22 (10.0%)	
	2	18 (8.2%)	2	8 (3.6%)	
	3	7 (3.2%)	3	4 (1.8%)	
	4	7 (3.2%)	4	2 (0.9%)	
	5	2 (0.9%)	5	0 (0.0%)	
	6	4 (1.8%)	6	0 (0.0%)	
	7	0 (0.0%)	7	1 (0.5%)	
	8	2 (0.9%)	8	1 (0.5%)	
	9 or more	1 (0.5%)	9 or more	0 (0.0%)	
	System missing	0 (0.0%)	System missing	0 (0.0%)	

* Indicates statistically significant reduction (p<.05) from pre-intervention

Appendix A-4: Urgent Care (ED) Visit Past 6 Months and Past year Pre- and Post-Intervention Mean Score Comparison Chart

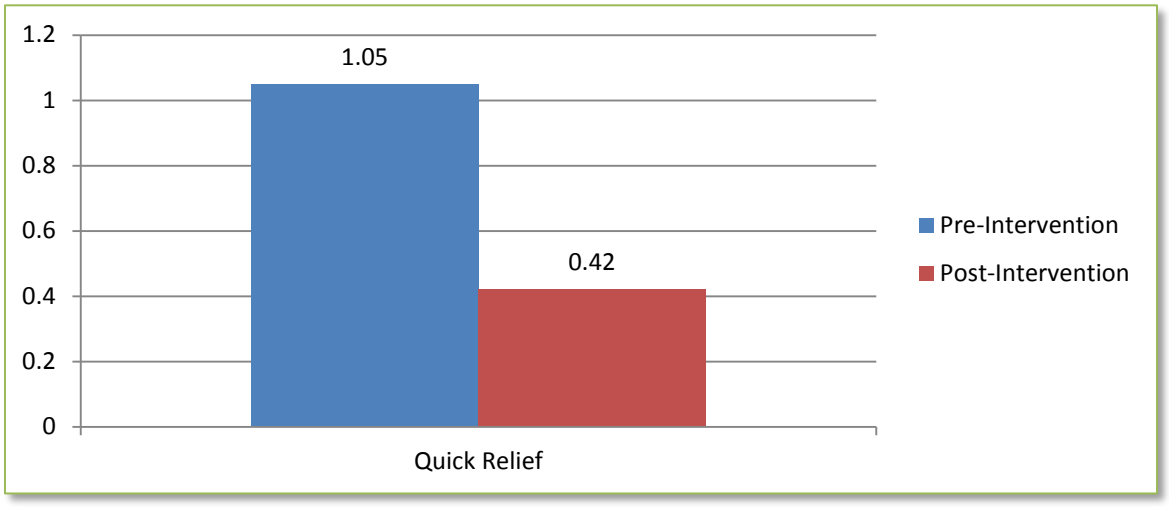


Appendix A-5: Use of Quick Relief Pre- and Post-Intervention Comparison Table[22]

	Pre-intervention		Post-intervention		
Use of Quick Relief (N=220)	Everyday	0 (0.0%)	Everyday	0 (0.0%)	t=10.685 df=219 p=.000*
	3-6 times/week	63 (28.6%)	3-6 times/week	13 (5.9%)	
	2 times/week or less	106 (48.2%	2 times/week or less	66 (30.0%)	
	None	51 (23.2%)	None	141 (64.1%)	
	System missing	0 (0.0%)	System missing	0 (0.0%	

* Indicates statistically significant reduction (p<.05) from pre-intervention

Appendix A-6: Use of Quick Relief Pre- and Post-Intervention Mean Score Comparison Chart



[22] Answer options were converted to numeric values for statistical analysis purpose: Use of Quick Relief (Everyday = 3) (3-6 times per week = 2) (2 times per week or less = 1) (None = 0)

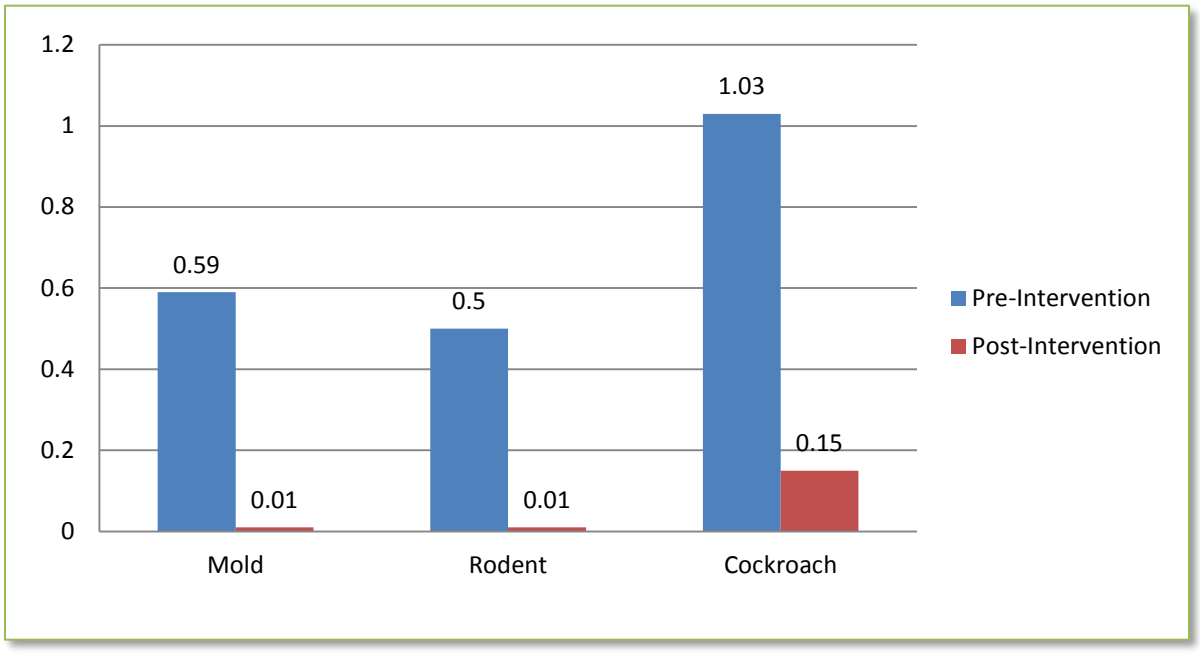
Appendix A-7: Home Environment Pre- and Post-Intervention Comparison Table[23]**

	Pre-intervention		Post-intervention		
Mold (N=168)	Bad	4 (2.3%)	Bad	0 (0.0%)	t=14.076 df=167 p=.000*
	Minor	96 (54.2%)	Minor	2 (1.1%)	
	None	77 (43.5%)	None	166 (93.8%)	
	System missing	0 (0.0%)	System missing	9 (5.1%)	
Rodent (N=168)	Bad	10 (5.6%)	Bad	0 (0.0%)	t=11.021 df=167 p=.000*
	Minor	69 (39.0%)	Minor	2 (1.1%)	
	None	98 (55.4%)	None	166 (93.8%)	
	System missing	0 (0.0%)	System missing	9 (5.1%)	
Cockroach (N=168)	Bad	29 (16.4%)	Bad	3 (1.7%)	t=12.737 df=167 p=.000*
	Major	4 (2.3%)	Major	0 (0.0%)	
	Minor	87 (49.2%)	Minor	17 (9.6%)	
	None	57 (32.2%)	None	150 (84.7%)	
	System missing	0 (0.0%)	System missing	7 (4.0%)	

* Indicates statistically significant reduction (p<.05) from pre-intervention

** The level of mold, rodent and cockroach measured at **kitchens/kitchen and dining rooms** in 177 housing units who have completed the follow-up inspection between 2010 and 2013

Appendix A-8: Home Environment Pre- and Post-Intervention Mean Score Comparison Chart



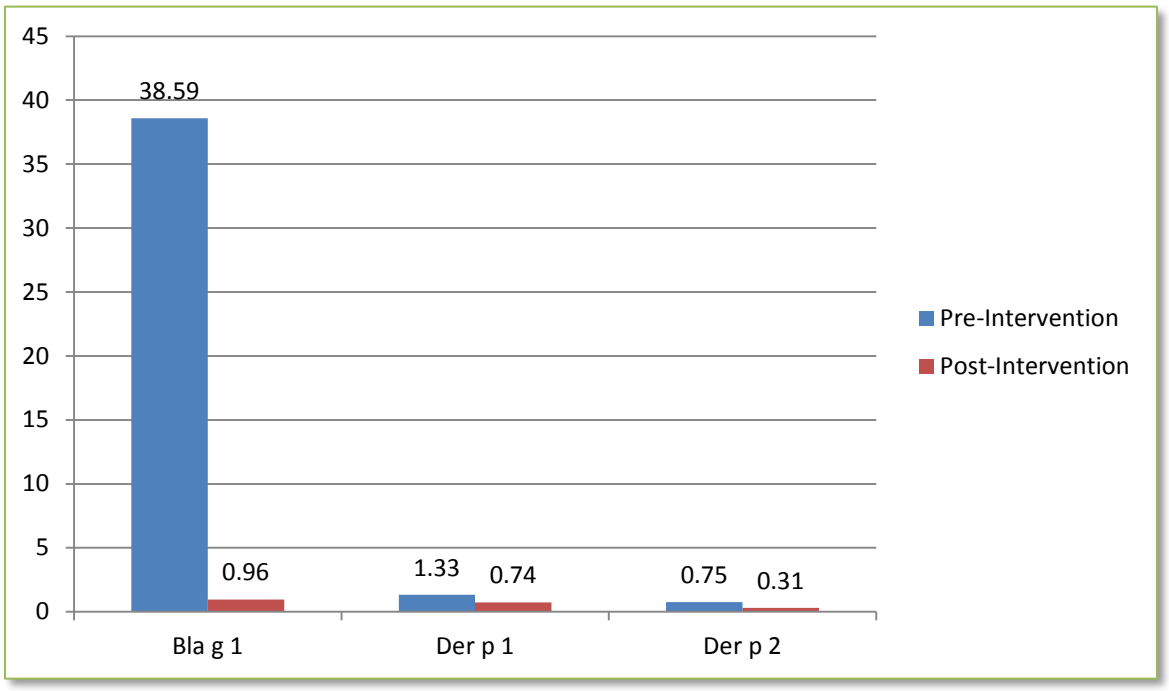
[23] Answer options were converted to numeric values for statistical analysis purpose: Mold (Bad = 2) (Minor =1) (None = 0), Rodent (Bad = 2) (Minor = 1) (None = 0) and Cockroach (Bad = 3) (Major = 2) (Minor = 1) (None = 0)

Appendix A-9: Cockroach Allergen Pre- and Post-Intervention Comparison Table

		Pre-Intervention	Post-Intervention	
Bla g 1 (N=144)	Mean	38.59 U/ml	0.96 U/ml	t=1.969
	Std. Deviation	238.16	9.28	df=143
	Minimum	0.00 U/ml	0.00 U/ml	p=0.051
	Maximum	2600.00 U/ml	110 U/ml	
Der p 1 (N=144)	Mean	1.33 ug/ml	0.74 ug/ml	t=1.079
	Std. Deviation	5.58	2.87	df=143
	Minimum	0.00 ug/ml	0.00 ug/ml	p=0.283
	Maximum	62.00 ug/ml	22.00 ug/ml	
Der p 2 (N=144)	Mean	0.75 ug/ml	0.31 ug/ml	t=3.719
	Std. Deviation	1.59	0.89	df=143
	Minimum	0.00 ug/ml	0.00 ug/ml	p=0.000*
	Maximum	12.00 ug/ml	6.30 ug/ml	

* Indicates statistically significant reduction (p<.05) from pre-intervention

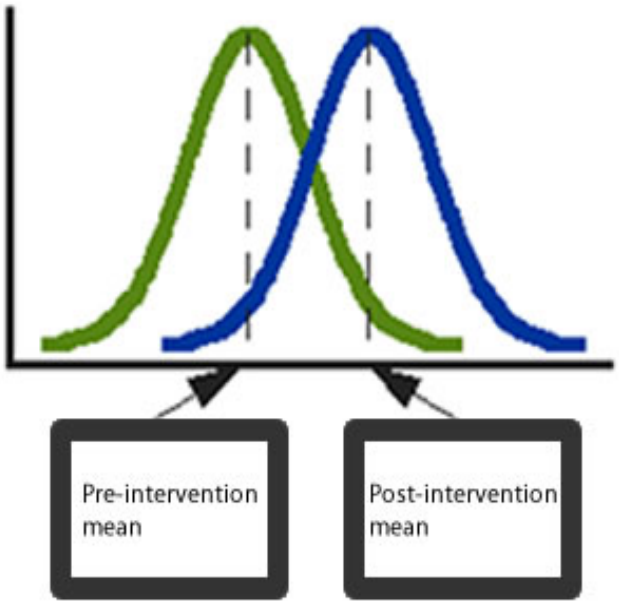
Appendix A-10: Cockroach Allergen Pre- and Post-Intervention Comparison Chart



Appendix B: Paired Sample T-test (Additional Note on Statistical Test of Pre and Post Comparison)

A paired sample t-test was used to assess whether the means of two groups (pre- and post-intervention) are statistically different from each other (see the figure below). This analysis is widely used in a pre- and post-intervention scenario (in psychology, clinical trial, etc.) where researcher examines the effectiveness of an intervention.

The effectiveness of the interventions is assessed by t-value, which represents the difference between the means of two groups (pre- and post-intervention means). However, a higher t-value does not necessarily imply a stronger effectiveness/significance. The significance of the effectiveness/difference is determined by a p-value, which is generated according to the t-value and degrees of freedom (see the table below). A statistical package like SPSS automatically calculates P-value, which statistically measures if the difference between the pre- and post-interventions means is large enough and, thus, is not likely to have happened by *chance.* In most social research, the alpha level is typically set up at 0.05, meaning that if p-value is less than 0.05, researchers accept that the difference between the pre- and post-intervention scores are statistically significant and not happened by chance, meaning that there is a scientific evidence that the intervention was effective.



Appendix B-1: Idealized Distributions for Pre- and Post-Intervention Group Comparison

t Distribution

	α					
Degrees of freedom	.005 (one tail) .01 (two tails)	.01 (one tail) .02 (two tails)	.025 (one tail) .05 (two tails)	.05 (one tail) .10 (two tails)	.10 (one tail) .20 (two tails)	.25 (one tail) .50 (two tails)
1	63.657	31.821	12.706	6.314	3.078	1.000
2	9.925	6.965	4.303	2.920	1.886	.816
3	5.841	4.541	3.182	2.353	1.638	.765
4	4.604	3.747	2.776	2.132	1.533	.741
5	4.032	3.365	2.571	2.015	1.476	.727
6	3.707	3.143	2.447	1.943	1.440	.718
7	3.500	2.998	2.365	1.895	1.415	.711
8	3.355	2.896	2.306	1.860	1.397	.706
9	3.250	2.821	2.262	1.833	1.383	.703
10	3.169	2.764	2.228	1.812	1.372	.700
11	3.106	2.718	2.201	1.796	1.363	.697
12	3.054	2.681	2.179	1.782	1.356	.696
13	3.012	2.650	2.160	1.771	1.350	.694
14	2.977	2.625	2.145	1.761	1.345	.692
15	2.947	2.602	2.132	1.753	1.341	.691
16	2.921	2.584	2.120	1.746	1.337	.690
17	2.898	2.567	2.110	1.740	1.333	.689
18	2.878	2.552	2.101	1.734	1.330	.688
19	2.861	2.540	2.093	1.729	1.328	.688
20	2.845	2.528	2.086	1.725	1.325	.687
21	2.831	2.518	2.080	1.721	1.323	.686
22	2.819	2.508	2.074	1.717	1.321	.686
23	2.807	2.500	2.069	1.714	1.320	.685
24	2.797	2.492	2.064	1.711	1.318	.685
25	2.787	2.485	2.060	1.708	1.316	.684
26	2.779	2.479	2.056	1.706	1.315	.684
27	2.771	2.473	2.052	1.703	1.314	.684
28	2.763	2.467	2.048	1.701	1.313	.683
29	2.756	2.462	2.045	1.699	1.311	.683
Large (z)	2.575	2.327	1.960	1.645	1.282	.675

Appendix B-2: T-distributions Table