ORNL/TM-2015/64

Survey of Recipients of Weatherization Assistance Program Services: Assessment of Household Budget and Energy Behavior Pre- to Post-Weatherization

Bruce Tonn
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OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

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Environmental Sciences Division

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ACRONYMS AND ABBREVIATIONS

ARRA	American Recovery and Reinvestment Act
CATI	Computer Assisted Telephone Interview
CFL	Compact Florescent Light
CFR	Code of Federal Regulations
DOE	Department of Energy
ECW	Energy Center of Wisconsin
LIHEAP	Low Income Home Energy Assistance Program
LMF	Large Multifamily
MH	Mobile Home
ORNL	Oak Ridge National Laboratory
OWIP	Office of Weatherization and Intergovernmental Program
PY	Program Year
SF	Single Family
SMF	Small Multifamily
SPSS	Statistical Package for the Social Sciences
WAP	Weatherization Assistance Program
WIC	Women, Infants and Children
Wx	Weatherization

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

This report presents in-depth analyses of survey data collected from recipients of services funded by the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP). WAP was created by Congress in 1976 under Title IV of the Energy Conservation and Production Act. Through WAP, DOE provides grants to states, territories, and Washington, DC (i.e. Grantees) to fund the weatherization of low-income homes. The Grantees provide grants to local weatherization agencies (also known as Subgrantees) to deliver weatherization services. Grantees and Subgrantees also leverage their DOE funds to acquire additional funds for low-income weatherization. Subgrantees accept applications for weatherization, confirm households' income eligibility for the program, conduct energy audits of the homes, install weatherization measures, and inspect each home post-weatherization. Common weatherization measures include: air sealing, wall and attic insulation, duct sealing, and furnace repair and replacement. The program operates across all climate zones in the United States, and weatherizes all manner of homes, from single-family detached units to mobile homes to large multifamily buildings.

In April 2009, DOE formally tasked Oak Ridge National Laboratory (ORNL) with conducting two impact and process evaluations of WAP, known as the retrospective and American Recovery and Reinvestment Act (ARRA or Recovery Act) period evaluations, respectively. The former focused on WAP Program Year (PY) 2008, which covers the period from April 2008 to June 2009. The latter focused on PY 2010. WAP differed significantly from one period to the next, in large part because ARRA included $5 billion in funding for WAP, a substantial increase over its typical annual appropriation of $230 to $250 million. Prior to these two studies, the most recent large-scale evaluation of WAP utilizing primary data was conducted in the early 1990s.

A task that bridged the retrospective and ARRA period evaluations was the administration of a national weatherization client (i.e., occupant, recipient) survey. Briefly, this survey included both a treatment group and a comparison group. Potential respondents for the treatment group were randomly selected from lists of single family and mobile homes about to be weatherized by 220 randomly selected Subgrantees. Potential respondents for the comparison group were randomly selected from lists of single family and mobile homes that were weatherized by these same Subgrantees one year previously. The approximately 45 minute phone survey was also administered post-weatherization, approximately eighteen months later, to both the treatment and comparison groups. The survey contained questions about energy end uses, energy consumption behavior, health, household budget issues, and demographics.

Two previous reports have utilized the data collected from the administration of this occupant survey. The first presented descriptive statistics for key questions using only the pre-weatherization results (Carroll et al. 2014a). The second used pre- and post-weatherization results pertaining to human health to estimate the monetary value of these non-energy benefits of low-income weatherization (Tonn et al. 2014a).

This report complements the other two reports. Specifically, it addresses three topics not thoroughly addressed by the previous reports: budget issues faced by WAP recipient households; energy conservation behaviors; and use of programmable thermostats.

WAP recipients can be characterized by the number of budget issues they face. For example, do they trade off purchasing food to pay utility bills or take on high interest, short-term loans to pay for other bills? Approximately 10% of households reported experiencing at least eight of ten serious budget issues. Another 13% experienced about six in ten issues. Conversely, almost half of the recipients experienced less than one in ten of the issues. Households that experienced the most budget issues were also much worse off with respect to other health and home conditions than households with few budget issues. The former experienced more flu, colds, and thermal stress events, and their homes had significantly more issues with respect to odors, mold, and infestations. Overall, households that are larger, live in larger

homes, have lower incomes, and are of working age experience more budget problems. These homes showed the most improvement post-weatherization across a large number of variables, though these households still faced more budget issues than most that received weatherization.

With respect to energy use, the results suggest that the weatherization process did not have significant impacts on household energy conservation behavior. For example, about the same number of households washed and dried their clothes with full loads (approximately 80% and 76%, respectively) pre- and post-weatherization. Rates for unplugging appliances (~27%) and hanging clothes out to dry (~37%) were also about the same. In a few cases, energy conservation behaviors increased post-weatherization (e.g., treatment homes purchasing Energy Star appliances increased from 60% pre-weatherization to 76% post-weatherization). In about an equal number of cases, energy conservation behavior decreased (e.g., 73% of comparison group homes purchased compact florescent lights (CFLs) pre-weatherization, dropping to 64% post-weatherization). Thermostat settings also showed little change post-weatherization, which suggests little or no take back of energy savings associated with home heating.

On the other hand, on average, the percentage of households that heated or cooled all of the rooms in their homes increased post-weatherization regardless of the number of rooms in the home or climate zone. Weatherization did not appear to impact the use of cross ventilation or methods to reduce heat gain in the summer (e.g., closing drapes).

Similar to the budget issue analysis, households can be clustered by their energy conservation behaviors. About 25% of the households exhibit less than 2 energy conservation behaviors (out of a core of six potential behaviors), whereas only 11% exhibit more than 4 (4.6 on average). Unlike the budget issue analysis, household energy conservation behaviors appear to be idiosyncratic. Very few independent and demographic variables correlate with energy conservation behaviors

Most of the analyses reported below suggest that client education as implemented by WAP has little to no impact on energy conservation behaviors post-weatherization. The number of client education "touches" (e.g., at time of the audit, at final inspection), the number of topics covered per touch, and the number of client education items given households were all insignificantly correlated with changes in energy conservation behaviors. Households that received specific client education on topics that related to specific energy conservation behaviors did no better with respect to energy savings than households that did not receive such client education. The only significant relationship found was this: separate client education visits had a positive and statistically significant impact on energy conservation behavior post-weatherization.

Use of thermostats is important with respect to household energy consumption. Almost every Subgrantee reported covering thermostat use as part of its energy education program. It was reported above that thermostat settings did not change much pre- to post-weatherization. It was also found that the use of programmable thermostats did not change appreciably post-weatherization. Households did not make use of the full capabilities of their programmable thermostats. Fewer households programmed, reprogrammed or overrode their programmable thermostats post-weatherization. Recipients' knowledge about thermostat operation is also deficient, as most households failed to correctly answer 3 of four basic questions about thermostat systems, both pre- and post-weatherization.

Overall, these results support two general conclusions. One, focusing weatherization on the 10-25% of households that suffer the most budget issues could yield the highest marginal returns with respect to health- and household-related non-energy benefits. Future research is needed to provide insights about what percentage of these weatherization households are also considered super-utilizers of medical services. Future research is also needed to determine whether households that could most benefit from weatherization from a health perspective are also homes that have the highest potential energy savings.

The second general conclusion is that there is ample space to improve how client education is implemented by WAP. The results suggest that separate client education visits are the most effective in changing energy conservation behaviors. Future research is needed to assess the benefits versus the costs with respect to expanding this intensive type of client education.

1. INTRODUCTION

This report presents in-depth analyses of survey data collected from recipients of services funded by the U.S. Department of Energy's (DOE) Weatherization Assistance Program (WAP). WAP was created by Congress in 1976 under Title IV of the Energy Conservation and Production Act. The purpose and scope of the Program as currently stated in the Code of Federal Regulations (CFR) 10CRF 440.1 is "to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users, and households with high energy burden." (Code of Federal Regulations, 2011)

Through WAP, DOE provides grants to states, territories, and Washington, DC (i.e. Grantees) to fund the weatherization of low-income homes. The Grantees provide grants to local weatherization agencies (also known as Subgrantees) to deliver weatherization services. Grantees and Subgrantees also leverage their DOE funds to acquire additional funds for low-income weatherization. Subgrantees accept applications for weatherization, confirm households' income eligibility for the program, conduct energy audits of the homes, install weatherization measures, and inspect each home post-weatherization. Common weatherization measures include: air sealing, wall and attic insulation, duct sealing, and furnace repair and replacement. The program operates across all climate zones in the United States, and weatherizes all manner of homes, from single-family detached units to mobile homes to large multifamily buildings.

In April 2009, DOE formally tasked ORNL with conducting two impact and process evaluations of WAP, known as the retrospective and American Recovery and Reinvestment Act (ARRA or Recovery Act) period evaluations, respectively. The former focused on WAP Program Year (PY) 2008, which covers the period from April 2008 to June 2009.[1] The latter focused on PY 2010.[2] WAP differed significantly from one period to the next, in large part because ARRA included $5 billion in funding for WAP, a substantial increase over its typical annual appropriation of $230 to $250 million. Prior to these two studies, the most recent large-scale evaluation of WAP utilizing primary data was conducted in the early 1990s[3]

The evaluations were designed to estimate energy savings, energy cost savings, non-energy benefits, and cost effectiveness. A national study on the impacts of weatherization on indoor air quality was conducted, along with numerous other studies including one on weatherization work quality[4] and another on the communication of weatherization outcomes through the social networks of weatherization recipients and staff.[5] In addition, surveys were administered to Grantees, Subgrantees, weatherization staff, and individuals who received weatherization-related training. Reports that summarize the findings from the retrospective[6] and ARRA period evaluations are available.[7]

Several evaluation tasks bridged the two evaluations. One such task was a national survey of weatherization recipients (i.e., clients, occupants). The survey was administered in two phases (roughly pre-weatherization and post-weatherization) during the Recovery Act period though its results benefitted both evaluations. The research approach is summarized briefly in Section 2.0 and described more thoroughly in Appendix A. The survey also provided the foundation for another survey that was used in a

[1] The retrospective evaluation plan (Ternes et al. 2007) can be found at http://weatherization.ornl.gov
[2] The ARRA period evaluation plan (Tonn et al. 2011) can also be found at http://weatherization.ornl.gov.
[3] See Brown et al. 1993.
[4] Berger, Lenahan, and Carroll 2014.
[5] Rose et al. 2014.
[6] Tonn et al. 2014b.
[7] Tonn, et al. 2015.

special study of the medical costs impacts of the Opportunity Council's[8] Weatherization Plus Health Initiative.[9]

The first of its kind survey of WAP recipients had several purposes and uses. First, the data provided insights into the demographics of the recipient population, their energy use behaviors, and health status. A separate report contains descriptive statistics collected during the first, pre-weatherization phase of the survey. [10] Second, the survey contained a client satisfaction component, administered a few months after it was anticipated weatherization was completed, to help the program understand its strengths and weaknesses from the perspective of the recipients.[11]

Third, many of the survey results were intended as inputs into a separate report on non-energy related health and household benefits of low-income weatherization.[12] This report presents descriptive statistics pre- and post-weatherization for almost all health-related questions contained in the survey, including results from questions pertaining to physical and mental health, asthma, thermal stress, and colds and flus. The report also presents statistical models relating independent variables to physical and mental health and rest/sleep and to asthma symptoms. Lastly, the report provides estimates of the monetary values for a dozen health and household-related non-energy benefits.

The research reported herein complements the first general survey results report and the more focused health and household related benefits report. This report explores data not previously analyzed and questions not previously addressed by the first two reports. The first topic explored below (in Section 3) is related to household budget issues faced by low income households. It has been noted for many years that low-income households face serious and stressful budget tradeoffs. When there is not enough money to pay all the bills, do households forego food, for example, to pay the utility bills or visa-versa? Or medical care? Or prescriptions? Results presented in the health non-benefits report suggest that many WAP households are regularly forced to make these tradeoffs; weatherization reduces this burden somewhat for many households. This report delves deeper for insights into how many tradeoffs households make and if some households make, on balance, more tradeoffs than others. These analyses are presented in Section 3.0.

Section 4 takes an in-depth look at household energy behaviors pre- and post-weatherization. This section presents descriptive statistics that describe common household energy behaviors (e.g., turning off the lights) pre- and post-weatherization. The survey asked numerous questions about thermostat use; these results are also summarized. The section explores whether there are some households that exhibit more energy efficient behaviors than others and if so, whether these households have defining characteristics. Data from a survey of Subgrantees on their client energy education actions was merged with these survey data to allow exploration of what types of actions, if any, prompt the most change in energy efficiency behaviors post-weatherization. How households use programmable thermostats pre- and post-weatherization is thoroughly addressed in this section. The section concludes with an exploration of the interactions between household budget issues and energy use behaviors.

[8] Opportunity Council is a weatherization agency located in Bellingham, Washington.
[9] Rose and Hawkins 2015.
[10] Carroll et al. 2014a.
[11] Carroll et al. 2014b.
[12] Tonn, Rose, Hawkins, and Conlon. 2014a.

2. SURVEY APPROACH

As mentioned above, a national occupant survey instrument was developed and administered, in part, to assess changes in household energy use, health and well-being post-weatherization. The approximately 45 minute phone survey was conducted in two phases. In phase 1, conducted in 2011, a random sample of households close to receiving the energy audits that preceded building weatherization was surveyed, along with a random sample of households that had been weatherized one-year previously. The first set of households was referred to as the treatment group and the second set was the comparison group. In phase 2, the same households from both groups were sampled one year to eighteen months later. The survey was implemented as follows:

- As part of the larger retrospective evaluation, 400 out of approximately 900 Subgrantees operating across the U.S. in PY 2008 were randomly selected to provide information to assist in the estimation of energy savings in natural gas and electric heated homes. From this subset, 220 were randomly sampled to participate in the occupant survey;

- In 2010, these Subgrantees were asked to furnish lists of single-family and mobile homes scheduled for audits at the time of the request and for lists of homes weatherized one year previously;[13]

- Homes were randomly selected from aggregated lists for the treatment and comparison groups, respectively;

- A computer-assisted telephone survey (CATI) was implemented, with a 70% response rate;

- The samples sizes for the treatment (*pre-weatherization*) and comparison homes (*one year post-weatherization*) were 665 and 803, respectively; and

- These same homes were re-surveyed in 2013, yielding 398 responses from the treatment homes (*post-weatherization*) and 430 from the comparison homes (*2-years post-weatherization*).

Lastly, it should be noted that 290 households surveyed to be part of the pre-weatherization treatment group had not had their homes weatherized by the time they were contacted to be part of the client satisfaction portion of the occupant survey. It is assumed that weatherization was deferred for these homes. The evaluation team attempted to re-contact this deferral group of homes as part of the second administration of the survey. One hundred-twenty two of these homes participated in the survey in the second phase, though none had received weatherization. These homes are not included in any of the analyses reported herein based on the assumption that they are not representative of weatherized homes.

[13] Households living in large multi-family (LMF) buildings were not included in the survey due to weatherization of these buildings being quite different from other housing stock. For example, a LMF weatherization job that replaced an old central boiler and a similarly old central hot water heater may not include many if any measures in the individual units. Renters living in LMF buildings with central heat and hot water who pay for energy through their rent may also not see any changes in their rent post-weatherization.

3. HOUSEHOLD BUDGET ISSUES PRE- TO POST-WEATHERIZATION

Past research on the energy burdens experienced by low-income households has noted that these households spend a considerably higher percentage of their income on energy than do non-low-income households.[14] Many studies have also found that low-income households will trade off life essentials (such as food and medicine) to pay their utility bills and vice-versa.[15] Sixty-five percent of our survey respondents reported pre-weatherization that it was hard or very hard to pay for energy bills; the percentage dropped to a still high 49% post-weatherization. One goal of the national occupant survey was to explore the character and extent of these types of tradeoffs amongst households that received WAP services.

These ten budget issues form the core for the analyses reported in this section[16]:

- Used one or more short-term, high interest loans (e.g., car title loan, pawn shop) during past year
- Paid other utility bills before energy bills during past year
- Paid energy bills before other utility bills during past year
- Paid energy bills before buying food during past year
- Bought food instead of paying energy bills during past year
- Household member went without food during last month
- Worried that cannot afford nutritious food during past month
- Could not afford prescriptions during past year
- Could not afford to see a doctor during past year
- Received food assistance (e.g., WIC) during past year

Table 3.1 indicates how frequently survey respondents encountered the budget problems listed above. Statistical tests were conducted over three pairs of variables: pre-weatherization treatment group and post-weatherization treatment group; pre-weatherization treatment group and comparison group one year post-weatherization; and comparison group one year post-weatherization and comparison group two years post-weatherization.[17] These three pairs are identified as (1), (2), and (3) in this table.[18] For example, 19% of the treatment group used one or more short-term, high-interest loans pre-weatherization. The percentage dropped to 12% post-weatherization, a statistically significant change (1). The difference in treatment households using at least one loan pre-weatherization and comparison group households surveyed one-year post-weatherization in the same time period is also highly statistically significant (2). The change in the use of short-term loans between the first time the comparison group was surveyed and the second times, while also encouraging, is not statistically significant (3).

Overall, the incidence of budget issues dealt with by treatment group households declined in every case pre- to post-weatherization (1) and also in every case for pre-weatherization treatment households compared to the one year post-weatherization comparison group households surveyed at the same time (2). Eight of ten of these pre- to post-weatherization treatment group changes were statistically significant

[14] Non-low-income households spend about 3% on residential energy versus 33% of income spent by households that earn less than $10,000 per year (ACCE 2012). Also see Power 2006.
[15] See Hernandez (2013) and Brunner et al. (2012).
[16] These ten items are similar to the eleven factors that comprise Colton's home energy insecurity scale (Colton 2003).
[17] Pearson's Chi Square was used for ordinal and dichotomous variables.
[18] All households surveyed in each group and each survey phase are included in analyses (1) and (3) rather than only homes that completed the survey both times. As noted in Section 2, not every home was characterized by every health-related issue considered here and the health-related issues that households do experience need not occur each year. For example, households do not experience thermal stress every year. Thus, it was determined to estimate changes between population groups. This decision also allowed for higher sample sizes for the statistical tests.

for each set of comparisons (1.2). These results support the conclusion that WAP can have beneficial impacts on the reduction of household budget stressors.

It should be noted that while in 8 of 10 cases the comparison group reported continued declines in budget issues from 1-year post-weatherization to 2-years post-weatherization, in only one instance was the change statistically significant. One can surmise that the impacts of weatherization on household budgets are more immediate than gradual.

Table 3.1 Household Budget Issues Pre- and Post-Weatherization

	Treatment Group		Comparison Group	
Survey Question	**Pre-WX**	**Post-Wx (1)**	**1-Year Post (2)**	**2-Years Post (3)**
Used one or more short-term, high interest loan (1=yes, 0=no)	19%	12%**	12%***	9%
How often not paid energy bills to pay other utility bills (1= every month, 3= every few months, 6= never)	5.06	5.33*	5.35**	5.39
How often not paid other utilities to pay primary energy bill (1= every month, 3= every few months, 6= never)	5.07	5.38**	5.31***	5.52**
How often not purchased food to pay energy bills past year (1= every month, 3= every few months, 6= never)	5.00	5.23**	5.31***	5.47
How often not paid energy bills to purchase food past year (1= every month, 3= every few months, 6= never)	5.31	5.55**	5.53***	5.62
Household member went without food (past 4 weeks) (1=yes, 0= no)	7%	5%	6%	5%
Worried household members wouldn't have nutritious food (past 4 weeks) (1=yes, 0= no)	23%	18%**	15%***	15%
Household member needed prescription medicines but couldn't afford (1= yes, 0= no)	33%	22%***	24%***	21%
Needed to see doctor but could not because of cost (1=yes, 0 = n0)	32%	24%**	25%**	21%
Received food stamps or WIC assistance past year (1=yes, 0= no)	56%	50%	50%*	50%

*** p<.001; ** p <.01; * p<.05; (1) Pre-Wx treatment vs. Post-Wx Treatment; (2) Pre-Wx Treatment vs. 1-Yr Post-Wx Comparison; (3) 1-Yr Post-Wx comparison vs. 2 Yr Post-Wx Comparison

An important question to explore is how many households within the WAP population suffer from all of these budget issues. Figure 3.1 presents the distribution of households surveyed in the first phase (i.e., in 2011) that suffered at any time the previous year from zero to all ten budget issues listed above by treatment and comparison group. This figure indicates that most homes suffer from few budget issues (<

2) though a fair number suffer from 8 or more issues. Table 3.2 indicates the change in budget issues suffered from one time period to the next for the treatment and comparison groups. The treatment group reported that the number of budget issues dropped by a statistically significant one-half issue whereas the comparison group's status remained unchanged.

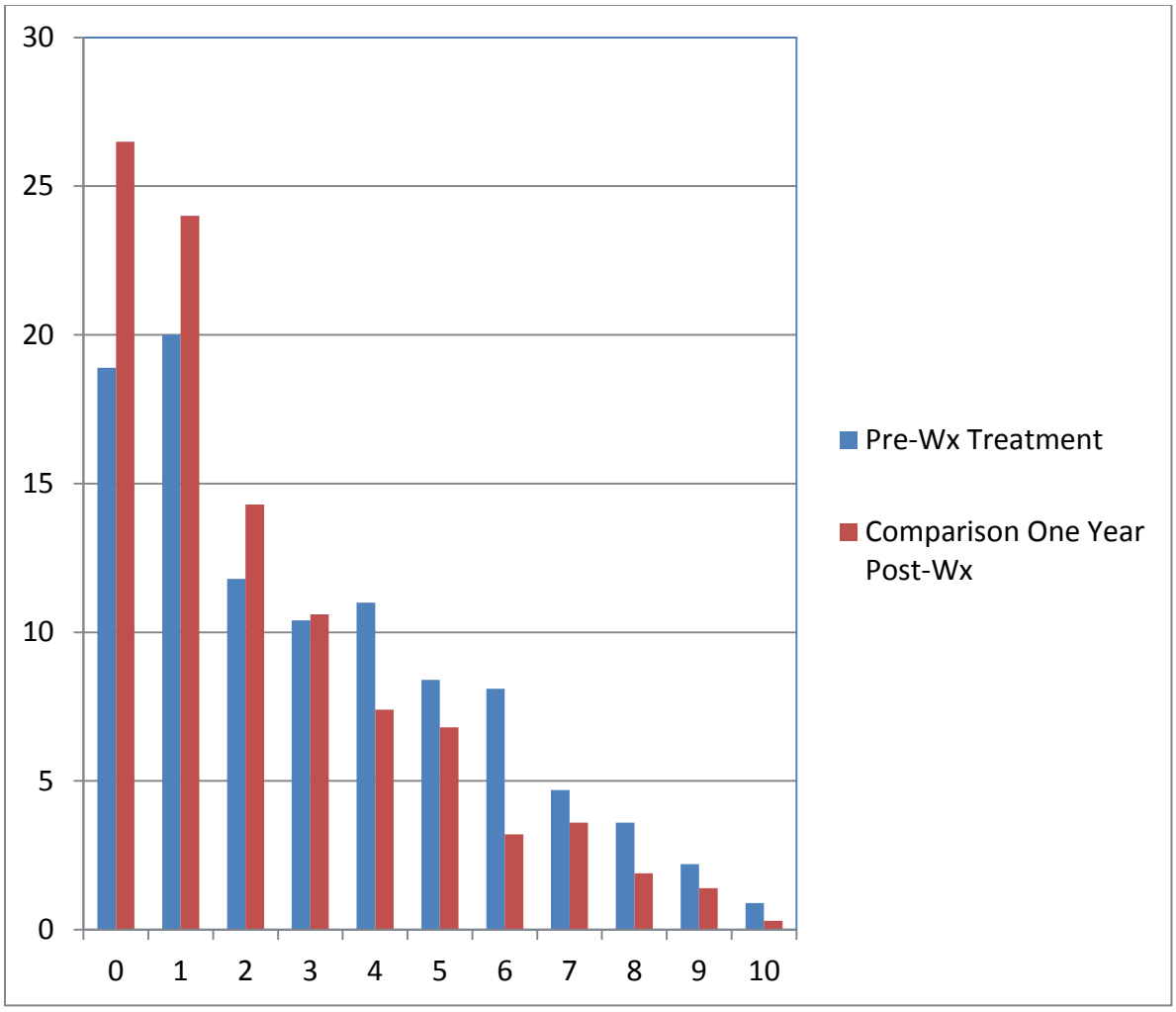

Figure 3.1 Distribution of Households by Number of Reported Budget Issues

Table 3.2 Average Number of Household Budget Issues: Pre- to Post-Weatherization

	Time Period 1	Time Period 2	Change
Treatment	2.8	2.3	-.51***
Comparison	2.2	2.1	-.03

*** p<.001; ** p <.01; * p<.05

In the medical community, the concept of super-utilizers has emerged as a powerful focus for reducing medical costs. Briefly, medical researchers have found that a small percentage of households account for a disproportionate share of the medical costs (e.g., Medicaid).[19] The medical community believes that extra efforts to address the needs of the super-utilizers will have high marginal benefits. The next question addressed herein is whether there is a weatherization analogue to medical super-utilizers.

[19] Coughlin and Long (2009).

To address this question, a cluster analysis, using the SPSS K-means cluster analysis function, was performed over all households in our pre-weatherization treatment group. Six clusters were specified and the clustering was over the ten budget variables listed above. Table 3.3 presents the results.

Table 3.3. Clusters of Households Dealing with the Ten Budget Issues (N=644)

Cluster #	1	2	3	4	5	6
Cluster Description	Food & Medical Issues	Worst Case	Food Issues	Pervasive Bill Trade-off Issues	Best Case	Utility Bill Issues
N (%)	75 (12%)	65 (10%)	37 (6%)	87 (13%)	301 (47%)	79 (12%)
Used one or more short-term, high interest loan	20%	58%	3%	37%	5%	23%
Paid other utility bills before energy bills	5%	95%	14%	97%	2%	81%
Paid energy bills before other utility bills	13%	95%	24%	92%	3%	77%
Paid energy bills before buying food	60%	86%	78%	67%	6%	6%
Bought food instead of paying energy bills	19%	88%	46%	95%	1%	0%
Household member went without food	9%	42%	16%	1%	0%	4%
Worried that cannot afford nutritious food	41%	95%	68%	11%	4%	6%
Could not afford prescriptions	72%	86%	62%	41%	7%	25%
Could not afford to see a doctor	100%	77%	0%	38%	7%	38%
Received food assistance (e.g., WIC)	55%	55%	62%	78%	43%	81%
Avg. # Issues Pre-Wx	3.9	7.8	3.7	5.6	0.8	3.4
Avg. # Issues Post-Wx	2.8	5.9	2.7	3.9	0.9	2.9
Change Pre- to Post-WX	-1.1	-1.9	-1.0	-1.7	+0.1	-0.5

The results clearly suggest that there is an analogue in the weatherization world. Households that fell into Cluster 2 (Worst Case), representing 10% of the sample, suffered almost eight budget issues pre-weatherization, with rates for using loans and confronting energy bill tradeoffs much higher than average. Conversely, a very sizable portion of households (47%), those falling into Cluster 5 (Best Case), reported suffering virtually no budget issues, less than one on average. The other four clusters fell within these two ranges. Households falling into Cluster 4, for example, face energy bill tradeoffs but fewer issues with respect to medically-related budget issues. Cluster 1 households report high rates of problems related to food and medical expenses. Clusters 2 and 4 had the highest reduction in budget issues post-weatherization, 1.9 and 1.7, respectively.

Figure 3.2 illustrates budget issues faced by the Worst and Best Case groups pre- and post-weatherization. While budget issues faced by the Worst Case group dropped in all cases post-weatherization, the percentage of those households that are experiencing almost all of these problems was still extremely high post-weatherization.

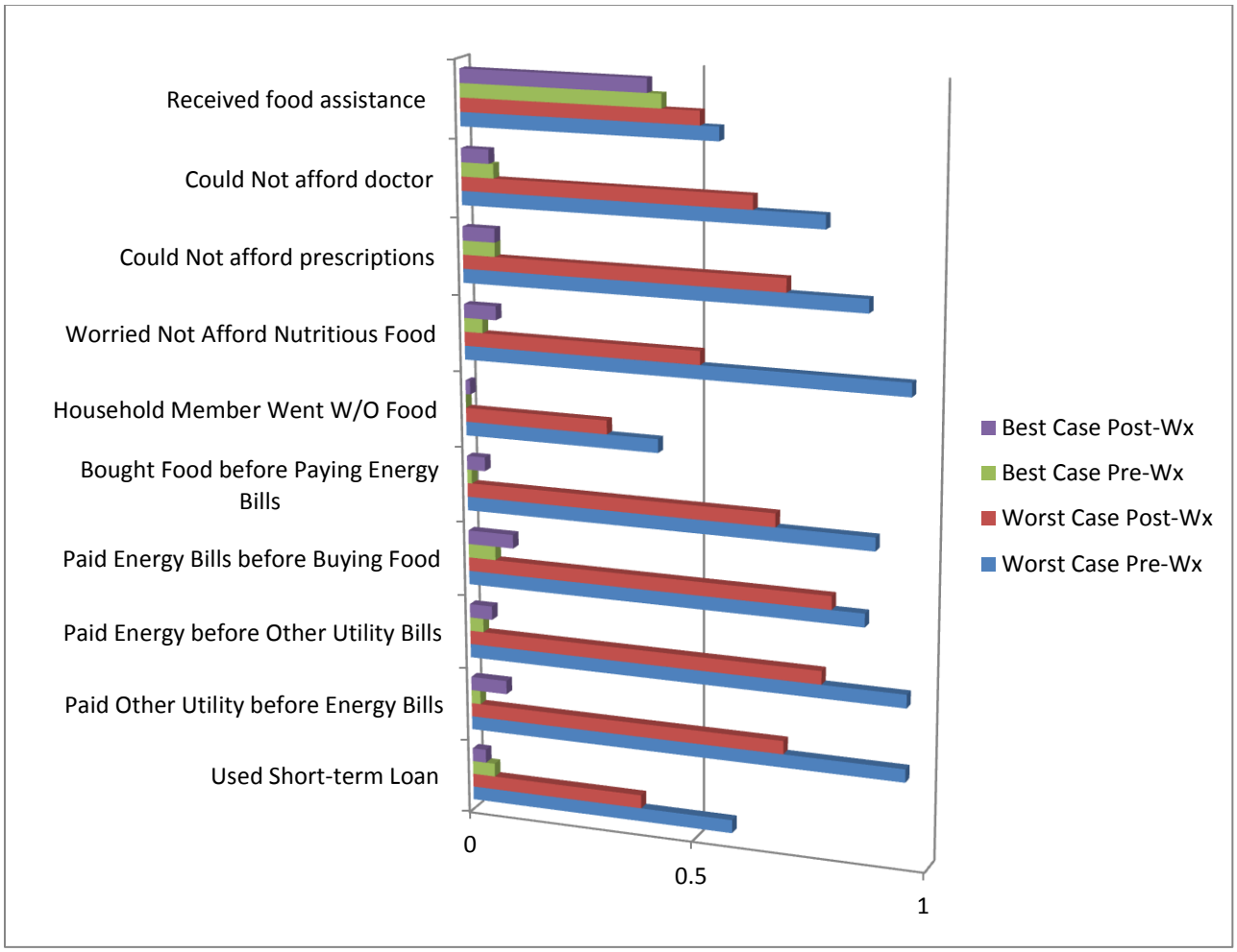

Figure 3.2 Budget Issues Faced by the Worst Case and Best Case Clusters Pre- to Post-Weatherization

The Worst Case and Best Case monikers attached to Clusters 2 and 5 are quite apt when other data are considered. By almost every measure, the former do indeed seem to be worse off than the latter. For example, consider Figure 3.3. The Worst Case cluster experienced significantly more days of bad physical and mental health pre-weatherization than the Best Case group. This is also the case with not getting enough rest and sleep. Figure 3.4 indicates that the Worst Case cluster households had much higher rates of headaches, flu, persistent colds, and bronchitis. Their homes were more often keep at unsafe temperatures, and unsurprisingly, these households needed more medical attention as a result of being too hot or too cold in their homes. Figure 3.5 indicates that the Worst Case group needed much more attention for medical care related to asthma and also experienced more asthma symptoms pre-weatherization. Lastly, Figure 3.6 indicates that the physical conditions in the homes of the Worst Case cluster were also worse, as measured by more odors, mold, pest and mice infestations, and standing water. Over almost all of these measures, the Worst Case households are still significantly worse off post-weatherization, at least as compared to the Best Case households (e.g., days not enough rest/sleep, flu and colds, mold).

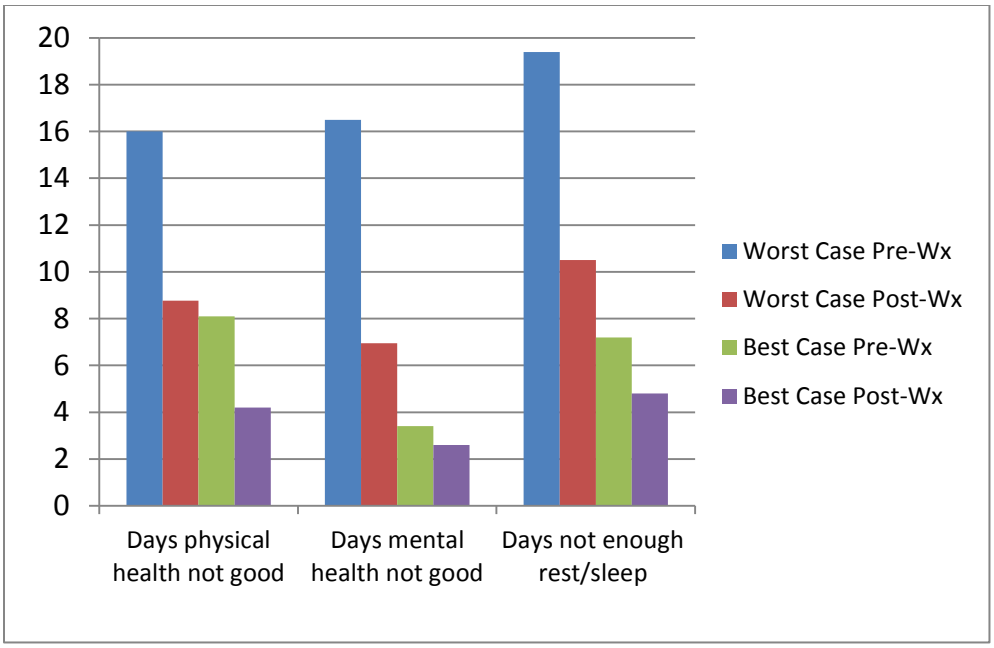

Figure 3.3 Cluster Results by Reports on Physical and Mental Health and Rest

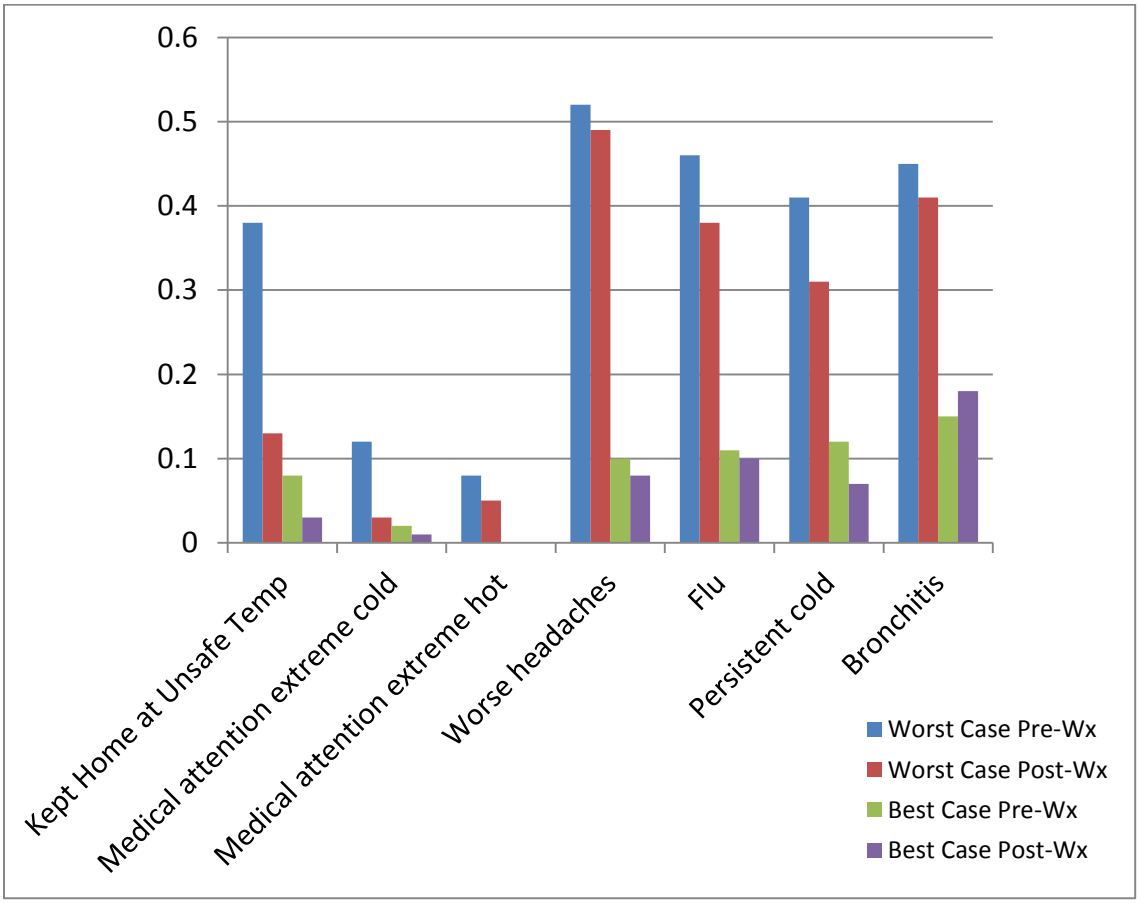

Figure 3.4 Cluster Results by Common Medical Problems

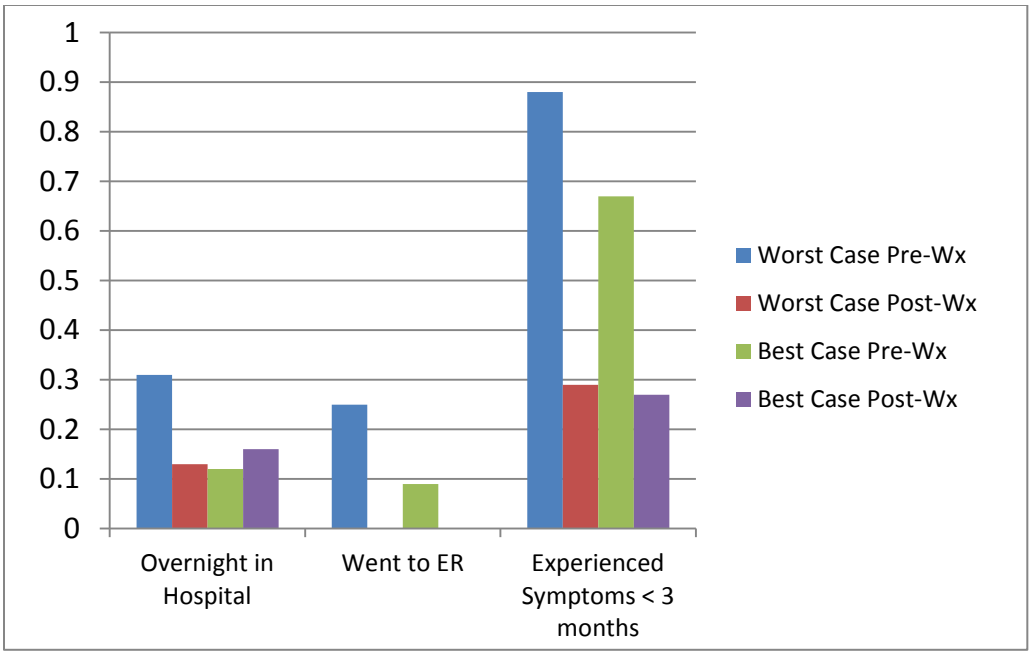

Figure 3.5 Cluster Results by Asthma-related Medical Care and Symptoms

Undoubtedly, there are numerous explanations for why some households suffer fewer budget, health and housing issues than others. The following analyses attempt to characterize the Worst Case and Best Case clusters using data collected in the national occupant survey. The results presented in Figures 3.7, 3.8, and 3.9 suggest that the Worst Case cluster of households have a lower annual income, and the respondents are somewhat younger and more likely to be of working age, respectively. A very high percentage of the primary respondents in the Best Case cluster are retired. These results suggest that stresses are much greater on working age households than on households with retirees.

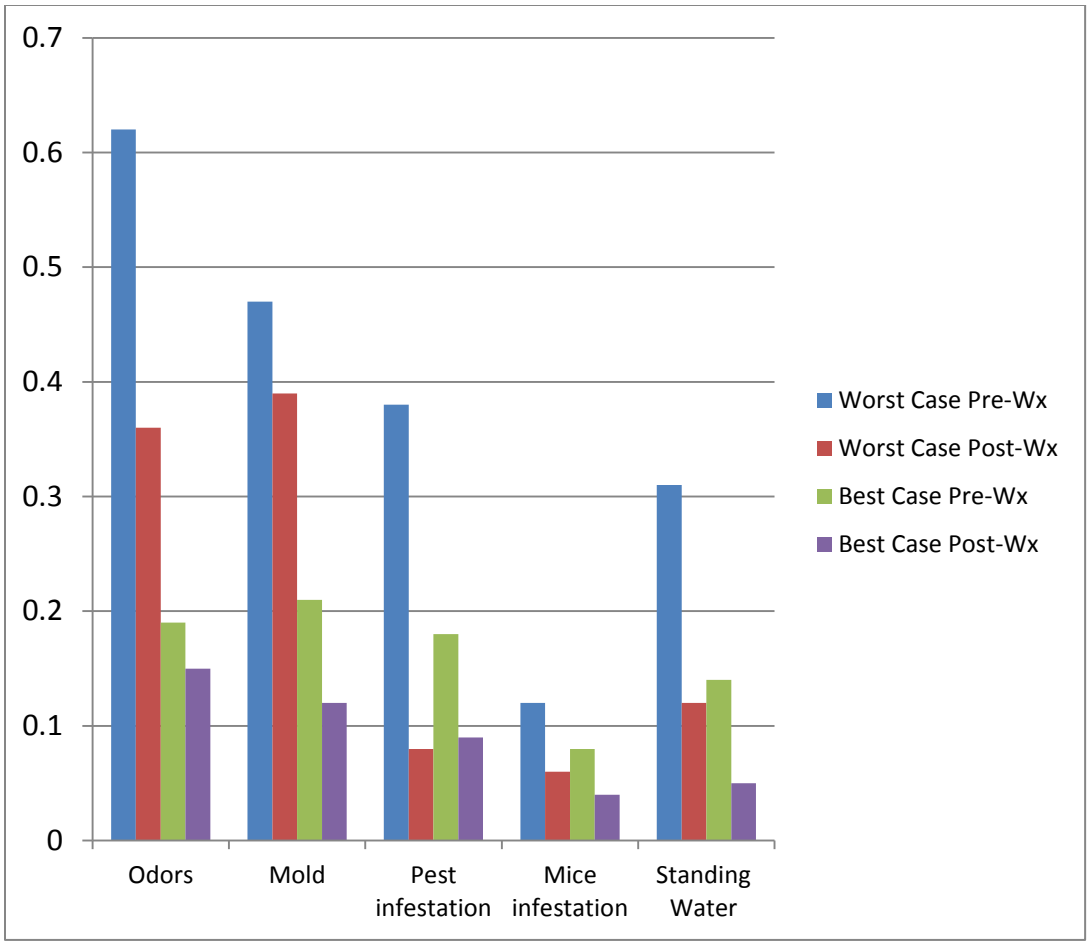

Figure 3.6 Cluster Results by Home Conditions

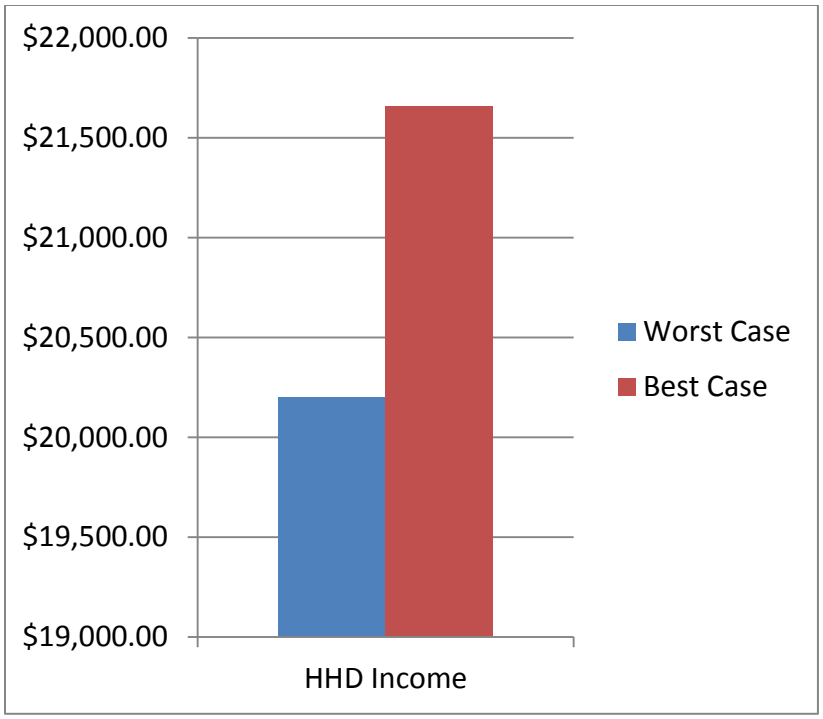

Figure 3.7 Cluster Results by Household Income

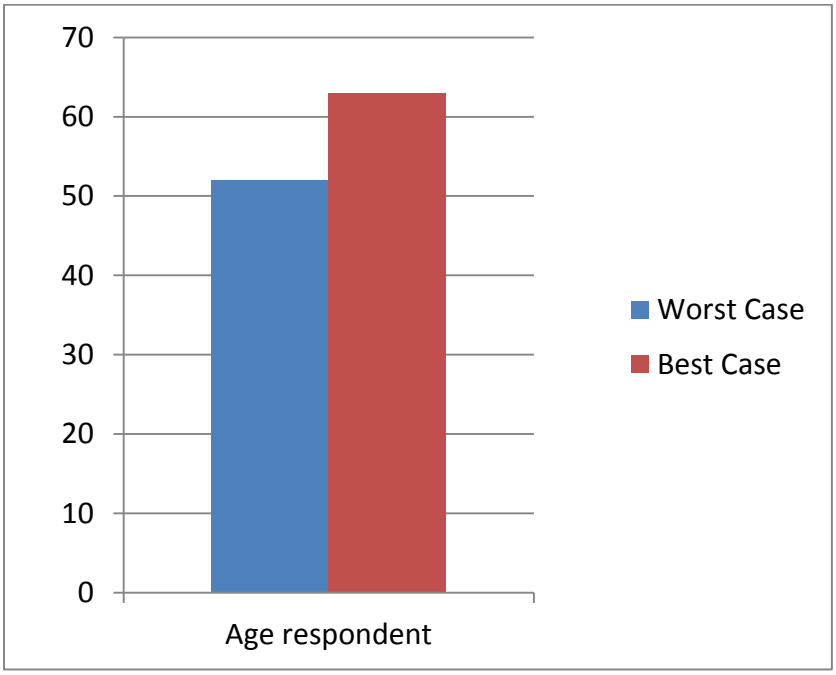

Figure 3.8 Cluster Results by Age of Respondent

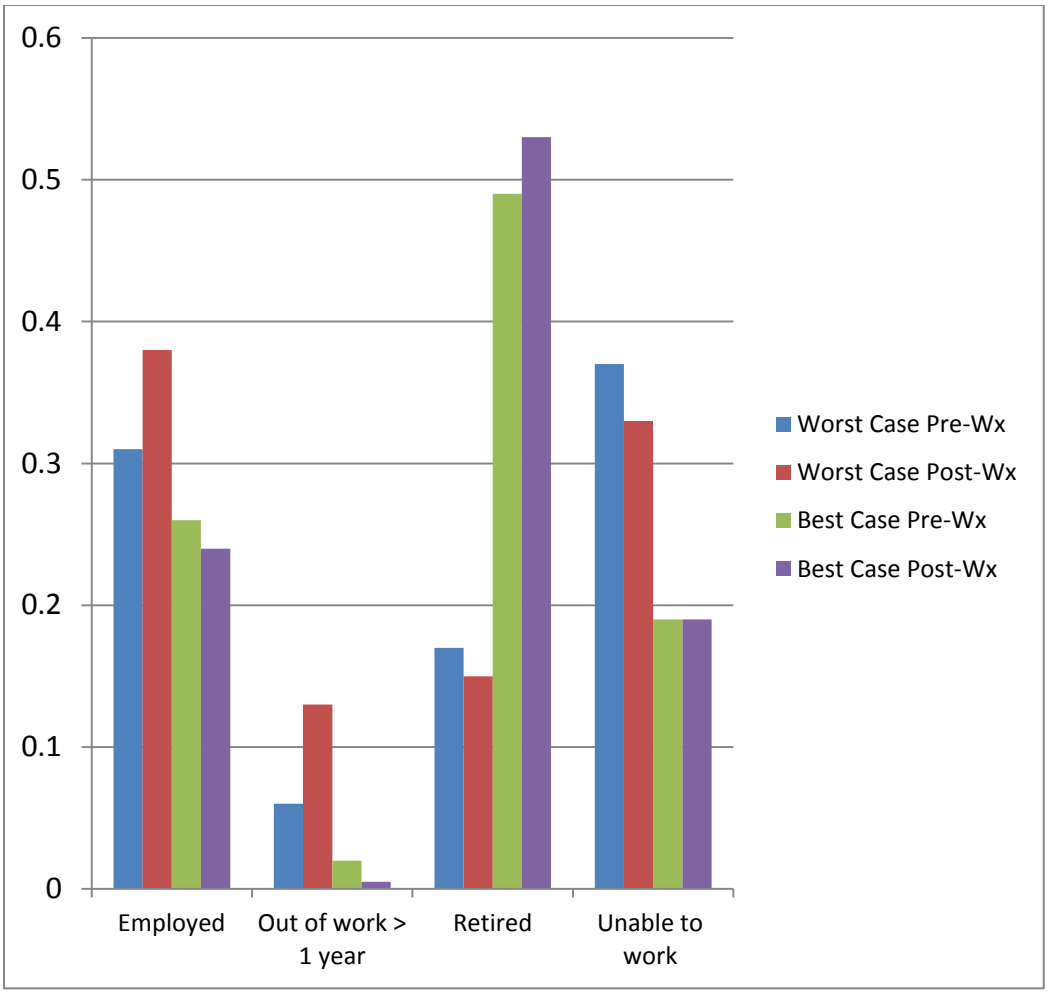

Figure 3.9 Cluster Results by Employment Status of Respondent

Table 3.4 presents the results of a regression model that specified the total number of budget issues faced per pre-treatment household as the dependent variable. The statistically significant independent variables confirm two of the observations just presented: those households where the respondent is retired experienced fewer budget problems as did households with higher annual incomes. Homes that heated with relatively expensive electricity, had more household members, were located in rural areas, and had a poor condition (as measured by mildew odor or musty smells) had more budget issues. Households living in mobile homes (which, on average, are smaller than single-family homes) and had health insurance coverage had fewer problems. With all of these other variables included in the model, the age of the respondent turned out not to be a significant variable and was dropped from the model. Other variables that dropped out of the model included: climate zone, whether the household received Low Income Home Energy Assistance Program (LIHEAP), was on a utility bill budget plan, and had health insurance that paid for prescriptions.

The regression results, not surprisingly, present a complex picture of the potential forces that influence household budget situations. Different supplemental income sources seem to have different influences. Where one lives and in what type of home also have differential influences. It should be strongly noted that this regression was not able to include variables that capture situations within families and households' relationships to their communities that could tremendously influence household situations (e.g., adolescent behavioral issues, neighborhood violence).

Table 4.4 Regression Results: Dependent Variable – Total Budget Issues (0-10)

Variable	Beta Coefficient	t-statistic	Significance
Constant	3.55	8.18	.000
Household size	.41	4.12	.000
Heating Fuel: Electricity (1=yes, 0=no)	.98	2.92	.004
House Type: Mobile Home (1=yes, 0=no)	-.78	-2.29	.023
Retired (1=yes, 0=no)	-1.39	-4.80	.000
Had Health Coverage Past 12 Months (1=yes, 0=no)	-1.33	-3.59	.000
Household Annual Income ($)	-2.91 E-5	-3.19	.002
Home is located in rural area (1-yes, 0=no)	.57	2.10	.037
Frequent mildew odor or musty smell (1=yes, 0=no)	1.30	4.65	.000

R^2 = .305, Adj. R^2 = .286 sig. =.000, N=307

In summary, this section delved into the household budget issue in more depth. It was found that weatherization can lessen household budget issues across the board. However, it was also found that a small percentage (10%) of households suffer from a disproportionate share of budget issues and that almost half (47%) suffer from very few. The first group of households also suffers from worse health and in-home conditions. This group tends to be of working age, or at least not of retirement age. One can imagine that these households are caught in a serious negative feedback loop, where bad health and home conditions impact the ability to earn an income, which then impacts budgets to the extent that food and prescriptions are regularly traded off of to pay utility bills (and vice-versa), which then impacts health and the ability to pay for up-keep of the home, and on-and-on. Weatherization does help improve the budget situations faced by the households but given the high rate of budget issues faced by over 50% of the households pre-weatherization, weatherization by itself is not a cure all.

4. ENERGY USE BEHAVIORS

This section addresses household energy use behaviors from three perspectives. First, in Section 4.1, descriptive statistics are presented that describe typical energy use and energy conservation behaviors pre- and post-weatherization. Section 4.2 assesses the influence of client energy education on energy use and energy conservation behaviors. The section concludes with an assessment of the use of programmable thermostats pre- and post-weatherization.

4.1 ENERGY USE BEHAVIORS: DESCRIPTIVE STATISTICS AND MODELS

This subsection addresses WAP household energy use behaviors pre- and post-weatherization. The national occupant survey included two dozen questions on this topic. The survey responses to many of these questions are presented in Table 4.1 by treatment and comparison group. By-and-large, energy use behaviors did not change much if at all pre- to post-wx for the treatment or from one-year post-weatherization to two years post-weatherization for the comparison group. For example, referring to the top row of Table 4.1, it is clear the microwave oven use did not change between time periods for either survey group. Other behaviors that did not change appreciably include: water temperature rinse cycle, and frequency of hanging clothes out to dry.

On the positive side, treatment group households substantially increased their use of exhaust fans when cooking (from 42% to 52%) and used their ovens less frequently to heat their homes. Treatment homes reported changing their air filters more often, being more familiar with the Energy Star label, and reducing the length of showers. In a couple of instances energy efficient behaviors increased in the treatment group but decreased in the comparison group: see purchasing CFLs and intentionally buying Energy Star appliances and electronics. Lastly, in three categories, energy efficiency behavior seems to have decreased in both survey groups: unplugging appliances, washing full loads of laundry, and setting washer temperatures in the wash cycle to cold. Overall, though, all of the behavior changes are relatively small and the beneficial changes seemed to be about equal to the changes leading to more energy use.

Home thermostat settings pre- and post-weatherization for the treatment and comparison groups are presented in Table 4.2. These results are more straightforward to interpret There was virtually no change in thermostat settings pre- to post-weatherization. Only one significant difference is noted, between the pre-weatherization treatment group's mean setting for when someone is home during the day during the winter to the same setting for the comparison group 1-year post weatherization. The latter setting is 0.4 ^{o}F higher than the former. From these results, one can conclude that the weatherization process did not lead to changes in thermostat use that would reduce energy consumption nor did the recipients take back energy savings by increasing their thermostat settings. [20, 21]

[20] Additional results on thermostat use and knowledge are also presented later in this chapter.

[21] This result is also consistent with indoor temperatures measured pre- and post-weatherization by the national Indoor Air Quality Study (Pigg 2014).

Table 4.1 Household Energy Use Behaviors Pre- and Post-Weatherization

	Treatment Group		Comparison Group	
	Pre-Wx	**Post-Wx**	**1-Year Post**	**2-Years Post**
Use Microwave Oven	96.4	96.2	97.1	96.3
Use exhaust fan regularly when cooking (yes)	41.7	52.4	49.5	48.0
How often used oven to heat house (never)	77.2	86.7	83.8	85.6
How often change air filter (monthly)	25.8	31.6	30.0	27.5
How often lights left on in unoccupied rooms (never/almost never)	65.8	65.3	61.1	56.4
Purchase or intentionally seek out CFLs (yes)	63.9	64.7	73.2	64.0
Familiar with Energy Star label (yes)	66.9	73.0	70.9	74.1
Bought/intentionally installed Energy Star appliances/electronics (yes)	59.7	76.0	75.9	69.5
Unplug appliances not in use (yes)	30.7	24.9	29.3	25.1
How often wash full loads of laundry (always, most of the time)	82.2	76.9	80.8	75.5
Water temperature of wash cycle (cold)	55.8	52.1	53.4	48.5
Water temperature of rinse cycle (cold)	85.1	85.6	86.1	83.9
How often dry full loads of laundry (always, most of the time)	78.1	76.3	77.6	74.0
How frequently hang cloths out to dry (very frequently, frequently)	38.3	35.0	39.6	38.6
Temperature of hot water heater adjusted (yes)	21.8	17.3	18.0	23.4
How temperature of hot water adjusted (cooler, much cooler)	50.3	62.3	52.5	50.7
How duration of showers has changed (decreased)	10.9	7.2	8.7	7.2
How duration of showers has changed (increased)	9.5	6.7	6.6	6.4

Table 4.2 Home Temperature Settings Pre- and Post-Weatherization (^{o}F)

	Treatment Group		Comparison Group	
	Pre-WX	**Post-Wx (1)**	**1-Year Post (2)**	**2-Years Post (3)**
Temperature Setting When Someone Home During Day During Winter	69.6	69.9	70.0*	70.3
Temperature Setting When No One Home During Day During Winter	67.2	67.3	67.3	67.5
Temperature Setting At Night During Winter	68.1	68.0	67.7	67.8
Temperature Setting When Someone Home During Day During Summer	73.8	74.4	73.8	73.9
Temperature Setting When No One Home During Day During Summer	75.0	74.8	74.6	74.7
Temperature Setting At Night During Summer	74.0	74.0	74.0	74.1

*** p<.001; ** p <.01; * p<.05; (1) Pre-Wx treatment vs. Post-Wx Treatment; (2) Pre-Wx Treatment vs. 1-Yr Post-Wx Comparison; (3) 1-Yr Post-Wx comparison vs. 2 Yr Post-Wx Comparison

The results pertaining to heating and cooling all rooms in recipients' homes post-weatherization are also less ambiguous. Figures 4.1 and 4.2 present figures that plot the number of rooms in a home by the percentage of homes with those number of rooms that heated and cooled all of their rooms, respectively, pre- and post-wx for the treatment group. The initial hypothesis was that the data would show that homes with fewer rooms would heat or cool more rooms post-wx (because they can now afford to) and homes with more than average rooms would condition fewer rooms (because through the energy education process they would learn the benefit of closing off extra rooms). As each figure shows, the percentage of households conditioning all of the rooms in their homes increased post-wx in almost all of the cases.[22]

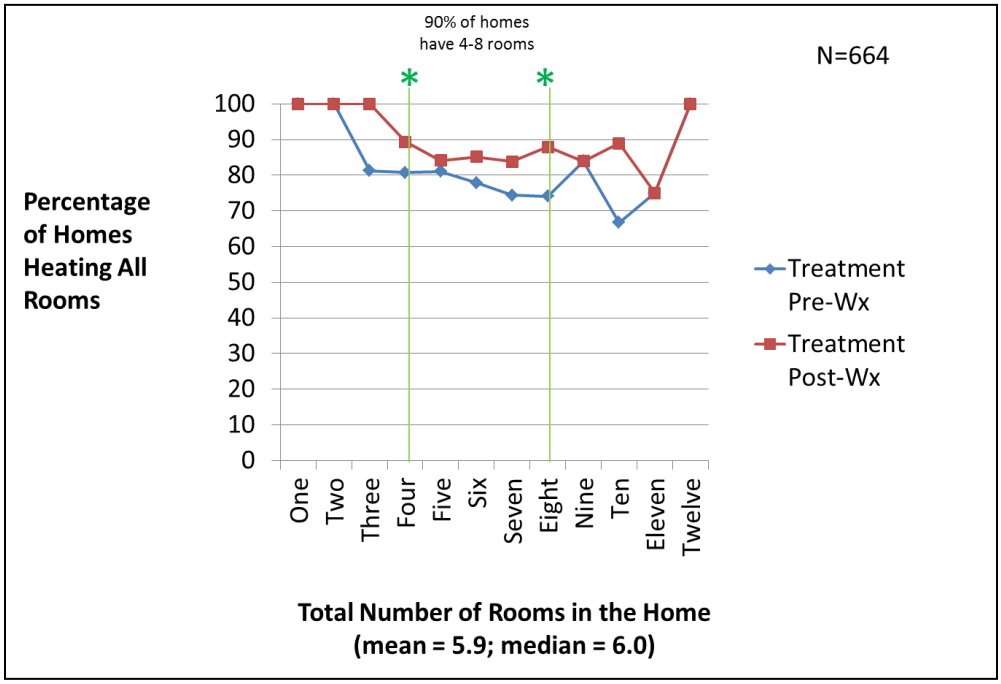

Figure 4.1 Percentage of Homes Heating All Rooms by Total Number of Rooms in the Home

Figures 4.3 and 4.4 show the percentage of homes heating and cooling all rooms, respectively, by climate zone. Figure 4.3 indicates that households in the moderate and hot regions were less likely to heat all of the rooms in their homes pre-weatherization and more likely to then heat all of the rooms post-weatherization. Figure 4.4 indicates that homes in these regions are more likely to air condition all of the rooms in their homes post-weatherization, though the biggest increase from pre- to post-weatherization occurred in the set of homes located in the cold climate region.

[22] The increase in homes heating all their rooms from pre- to post-weatherization is not statistically significant as a group. The increase in air conditioning of all rooms post-weatherization is statistically significant, p=.035.

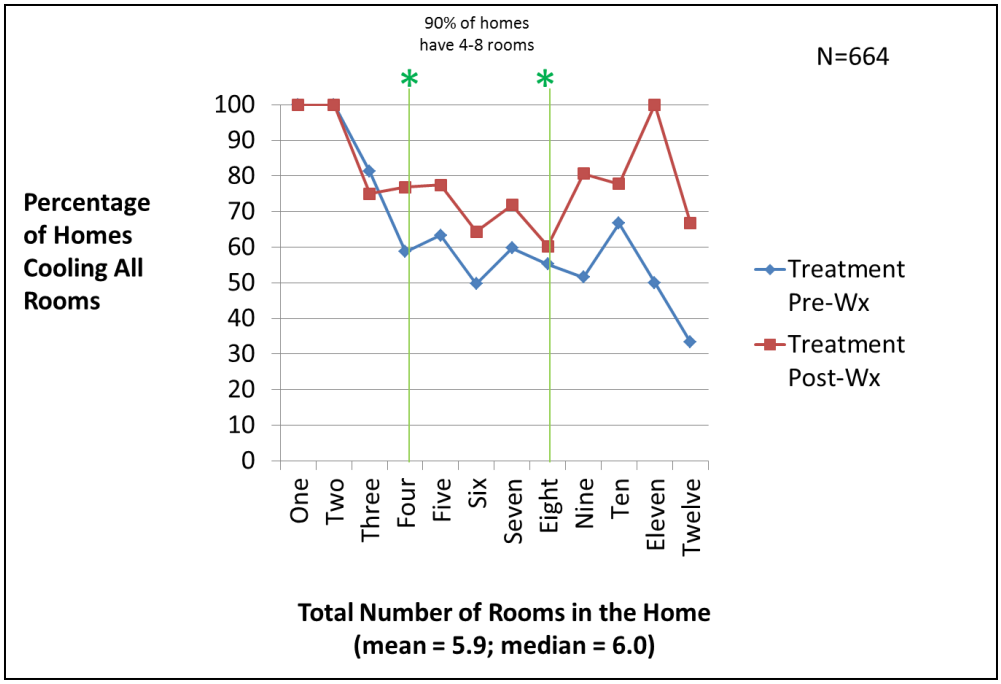

Figure 4.2 Percentage of Homes Cooling All Rooms by Total Number of Rooms in the Home

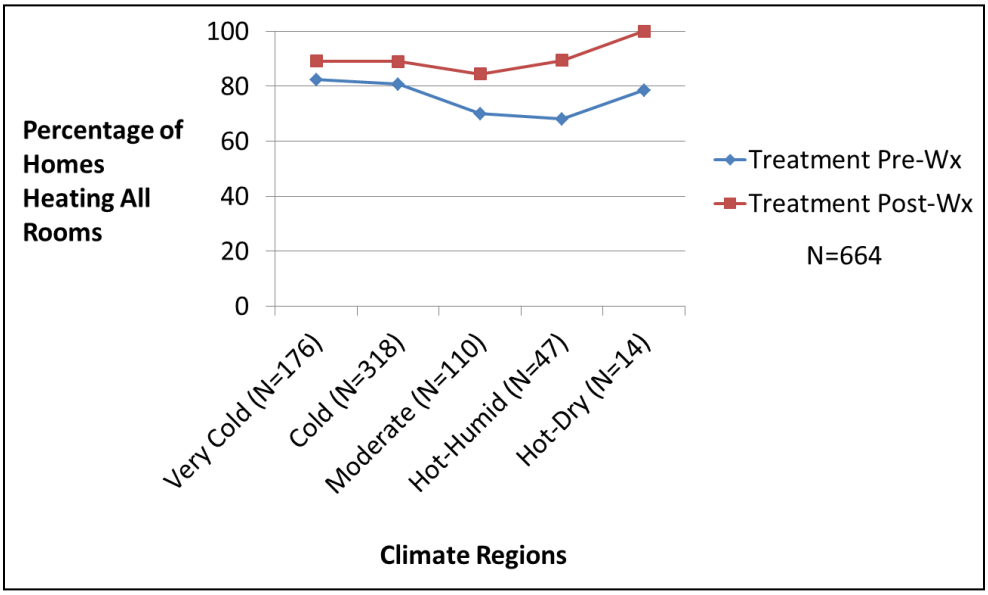

Figure 4.3 Percentage of Homes Heating All Rooms by Climate Region

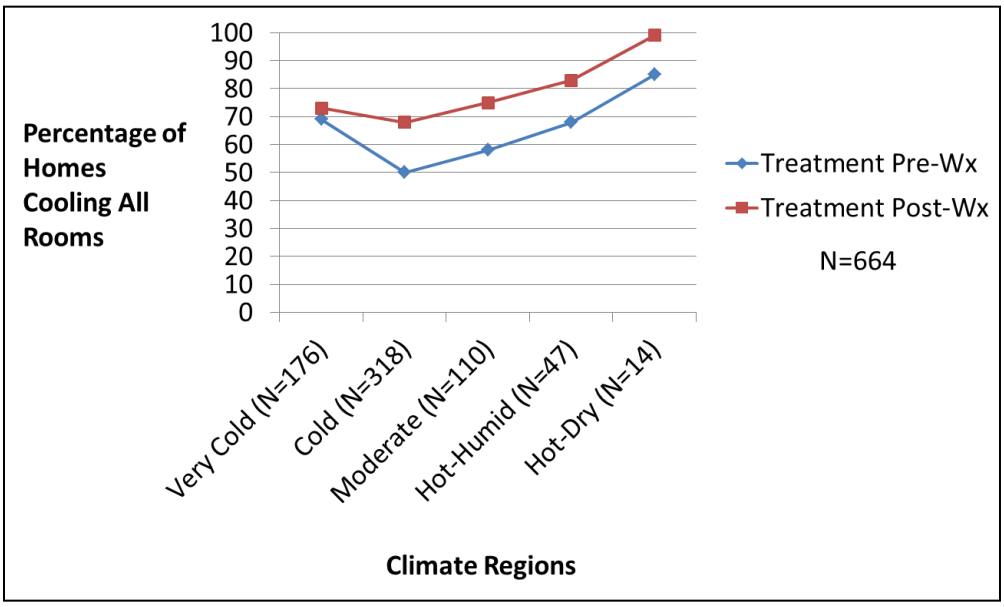

Figure 4.4 Percentage of Homes Cooling All Rooms by Climate Region

In addition to altering thermostat settings and behaviors with respect to conditioning all or fewer rooms in homes, weatherization recipients could also open their windows more often, use cross ventilation to cool their homes, and also close drapes, curtains, etc. to reduce heat gain inside during the summer. Figure 4.5 presents the results for the treatment group of opening windows more often during the winter and summer periods. The top two lines depict the percentage of homes that reported never opening their windows during the winter across climate zones. The relationship between the plotted lines indicates that households actually open their windows more post-weatherization. On the other hand, window use in the summer, depicted by the red and blue lines, is virtually unchanged across climate zones, except for the hot-dry climate zone, which it should be noted has a very small sample size.[23]

[23] It should be noted though that overall, the reduction in never opening windows was statistically significant (p=.002) as was the reduction in never opening windows in the winter (p=.000)

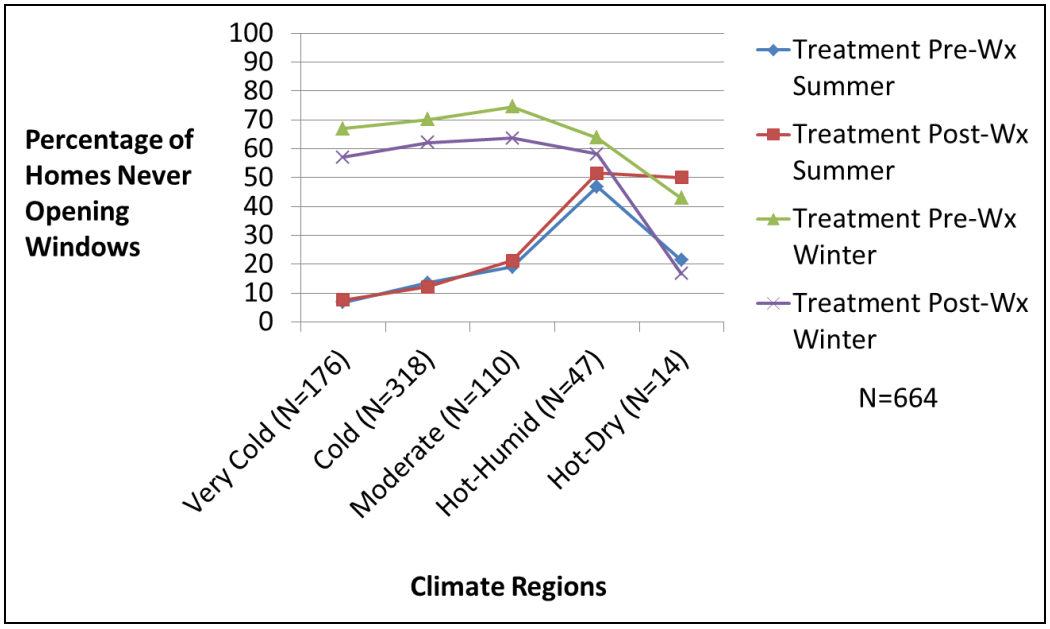

Figure 4.5 Percentage of Homes Never Opening Windows by Season by Climate Region

Figure 4.6 presents results related to cross ventilation and heat gain prevention measures. With respect to the former, similar to window use in the summer, there is little change with respect to the treatment groups' use of cross ventilation (see the green and blue lines) from pre- to post-weatherization, again except for the small sample size hot-dry group.[24] The story is essentially the same with the heat gain behaviors except that the households in the moderate climate zone increased their use of heat gain behaviors by around 5%.[25]

[24] These changes were not statistically significant.
[25] Overall, the changes in heat gain behavior were statistically significant (p=.000).

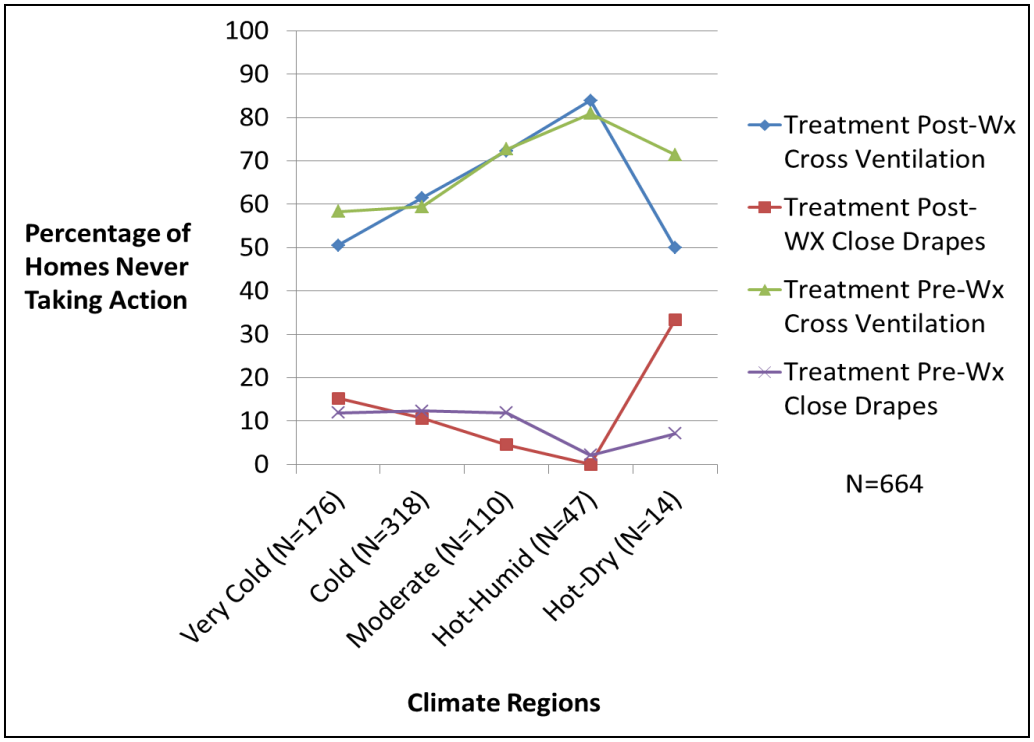

Figure 4.6 Percentage of Homes Never Using Cross Ventilation or Closing Drapes, Curtains, Etc. to Block the Sun in the Summer Months by Climate Region

Six energy-related behaviors were selected from Table 4.1 as the basis for further analysis. They were selected because they are behaviors that can be pursued regardless of house type, climate zone, heating system type or heating fuel used. The six behaviors are:

- Purchase CFLs
- Bought Energy Star Product
- Unplug Appliances
- Hang Clothes Out to Dry
- Wash Clothes in Cold Water
- Never Leave Lights On

Table 4.2 presents the mean number of the behaviors exhibited by the treatment and comparison homes from the first implementation of the occupant survey to the second implementation. While the treatment group, on average, increased the number of energy beneficial behaviors, the increase was not statistically significant. On the other hand, the comparison group, on average, decreased their energy conservation behaviors somewhat 2-years post weatherization and that change is statistically significant. This finding supports in another way observations made about the results presented in Table 4.1.

Table 4.2 Average Number of Energy Reduction Behaviors: Pre- to Post-Weatherization

	Time Period 1	Time Period 2	Change
Treatment	3.06	3.20	0.14
Comparison	3.29	2.92	-.37***

*** p<.001; ** p <.01; * p<.05

A cluster analysis was conducted similar to the one described in Section 3. The six variables listed above were used to place the treatment (pre-weatherization) households into six clusters. Table 4.3 contains the results. Similar to the budget problem cluster analysis, two clusters emerged that represent groups that exhibit a low level of energy conservation behaviors and a high level, clusters 1 and 2, respectfully. The only energy conservation behavior that the households in cluster 1 exhibit at a relatively high rate is buying Energy Star products. Conversely, the only energy conservation behavior that the cluster 2 households relatively shun is purchasing CFLs. The households that fell into clusters 3 and 4 exhibit lower levels of energy conservation behavior but their characterization is challenging, so they are simply labeled idiosyncratic. For example, one might expect that households that buy CFLs might also purchase Energy Star products, which is the case for cluster 4 but is not the case for cluster 3. With respect to cluster 4, one might expect that households that take the time to unplug appliances and hang clothes out to dry would also never leave the lights on but that is not the case. The behaviors exhibited by households falling into cluster 5 and 6 are less idiosyncratic. Still, cluster 6 households buy CFLs but leave their lights on whereas cluster 5 houses do not. Cluster 6 households will take the time to unplug appliances but not to hang clothes out to dry whereas cluster 5 households do both. Overall, it appears from these results that energy conservation behaviors do not readily fit into neatly explainable patterns at least with respect to this method of analysis.

Table 4.3 Clusters of Households by Common Energy Behaviors (N=266)

Cluster #	1	2	3	4	5	6
Cluster Description	Least # of Energy Cons. Behaviors	Most # of Energy Cons. Behaviors	Idiosyncratic 1	Idiosyncratic 2	Buy Conservation Measures Plus Never Leave Lights On	Buy Conservation Measures Plus Wash in Cold Water
N (%)	65 (24%)	30 (11%)	47 (18%)	22 (8%)	47 (18%)	55 (21%)
Purchase CFLs	34%	37%	89%	32%	96%	100%
Bought Energy Star Product	60%	73%	13%	5%	96%	87%
Unplug Appliances	8%	70%	15%	68%	60%	7%
Hang Clothes Out to Dry	2%	93%	13%	73%	23%	63%
Wash Clothes in Cold Water	40%	93%	85%	32%	28%	96%
Never Leave Lights on	17%	97%	74%	23%	72%	20%
Avg. # Behaviors Pre-Wx	1.6	4.6	2.9	2.3	3.7	3.7
Avg. # Behaviors Post-Wx	2.3	4.3	3.2	2.6	3.5	3.7
Change Pre- to Post-WX	.56	-.33	.19	.4	-.29	-.1

Table 4.4 describes the six clusters over several demographic and climate variables. There are few discernable patterns to be found in this table. As one might expect, the households with the highest incomes, cluster 1, exhibit the least number of energy conservation behaviors. On the other hand, the households the exhibit the most, cluster 2, do not report the lowest incomes. All of the households report about the same number of budget problems. Figure 4.7 presents energy conservation behaviors pre- and post-weatherization for the Worst and Best Case household budget problem clusters. No discernable patterns emerge from this figure to link energy conservation behaviors with household budget issues. Turning back to Table 4.4, the ages of the respondents, the location of the homes by climate zone, home ownership and house type also do not have patterns that are readily interpretable with respect to energy behaviors.

Table 4.4. Characteristics of Households by Energy Behavior Clusters

Cluster #	1	2	3	4	5	6
Cluster Description	Least	Most	Idiosyncratic 1	Idiosyncratic 2	Buy Conservation Measures Plus Never Leave Lights On	Buy Conservation Measures Plus Wash in Cold Water
Age of Respondent	52	54	57	47	58	50
Household Income	$29,800	$20,300	$18,600	$14,400	$22,000	$22,800
# Budget Problems (max = 10)	3.0	3.4	3.0	3.8	3.3	3.7
Climate Zone Very Cold	17%	43%	30%	23%	23%	36%
Climate Zone Cold	60%	27%	55%	59%	53%	51%
Climate Zone Moderate	18%	23%	10%	13%	13%	7%
Climate Zone Hot	4%	7%	4%	10%	11%	55
Single Family	71%	60%	62%	64%	75%	86%
Mobile Home	20%	30%	32%	36%	15%	13%
Own	89%	90%	89%	86%	89%	93%

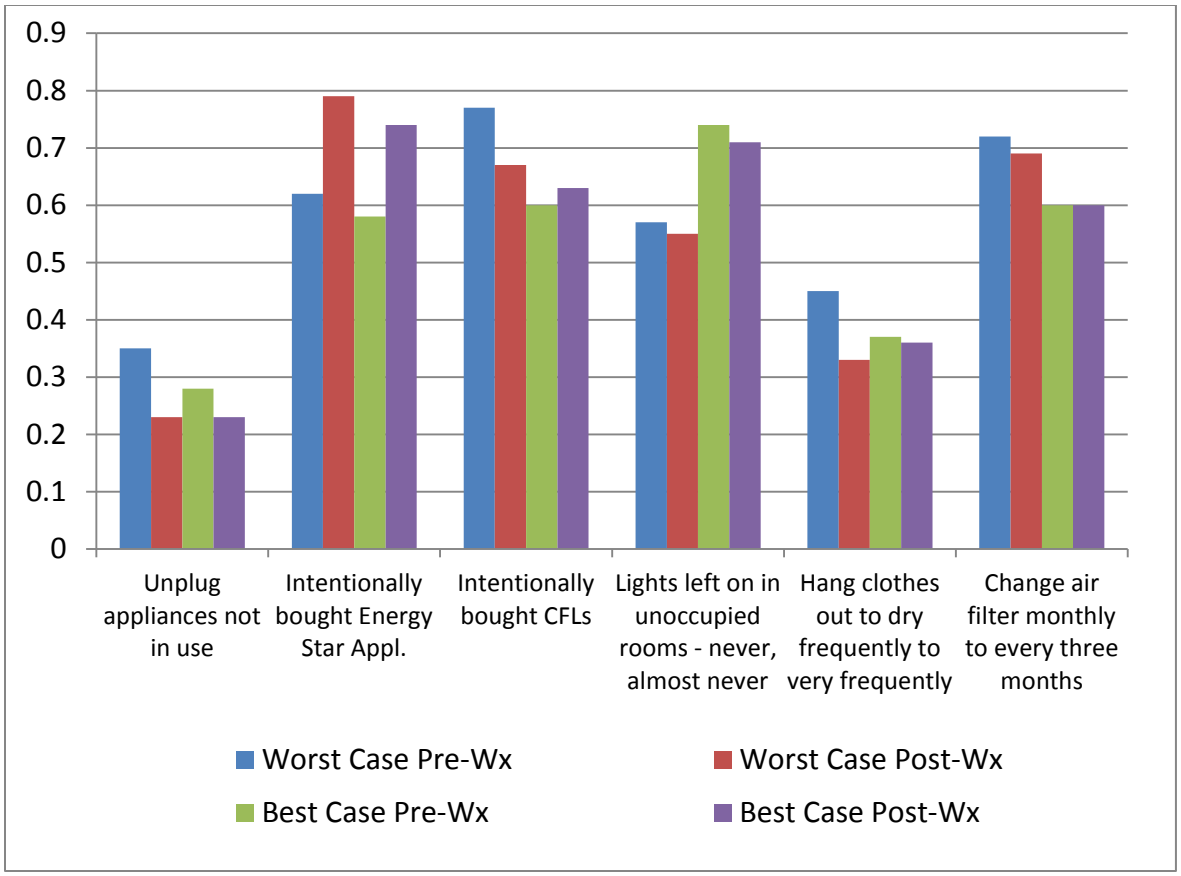

Figure 4.7 Energy Conservation Behaviors by Worst and Best Off Household Budget Problem Clusters

Also similar to the analyses presented in Section 3, a regression model was estimated, where the dependent variable was the number of energy conservation behaviors exhibited. While the model presented in Table 4.5 is statistically significant, it does not explain a significant amount of the variation in the dependent variable, as indicated by the low R^2 and Adj. R^2. This is another strong indicator that energy conservation behavior is idiosyncratic, at least with respect to the independent variables available to this research. A few independent variables are or are close to being statistically significant. For example, larger households exhibit fewer energy conservation behaviors. Lack of good mental and physical health both are correlated with fewer energy conservation behaviors, possibly suggesting that energy conservation requires clear minds and personal energy. Households that understand their energy bills well exhibit more energy conservation behaviors, an interesting tie between knowledge and behavior. On the other hand, the educational attainment of the respondent was highly statistically insignificant. Other highly insignificant variables that were dropped from the model include: number of budget problems, house type, age of respondent, heating fuel, climate zones, home ownership, condition of the home, use of short-term high-interest loans, and employment status of the respondent.

Table 4.5 Regression Results: Dependent Variable – Total Energy Efficient Behaviors (0-6)

Variable	Beta Coefficient	t-statistic	Significance
Constant	3.32	9.92	.000
Gender of Respondent (1=male, 2=female)	.262	1.71	.088
Number of days past month physical health not good	-.009	-1.47	.144
Number of days past month mental health not good	-.014	-2.03	.043
Employed (1=yes, 0=no)	-.198	-1.23	.218
Rural Home Location (1=yes, 0-no)	.226	1.57	.118
Household on Utility budget plan (1=yes, 0=no)	-.144	-1.03	.303
How well understand information on energy bill (1=very well, 3=Neither well nor not well, 5=Not well at all)	-.101	-1.75	.081
Household size	-.089	-2.11	.036

R^2 = .089, Adj. R^2 = .065 sig. =.000, N=317

4.2 IMPACTS OF CLIENT ENERGY EDUCATION ON ENERGY BEHAVIORS

This subsection assesses the impact of client education delivered by Subgrantees to weatherization recipients on energy conservation behaviors. To accomplish this task, the occupant survey data were merged with data collected from Subgrantees on their client education activities through the S3 Sampled Agencies Detailed Program Information Survey.[26] The occupant survey and Subgrantee records were matched using an anonymized Subgrantee ID number.

The Subgrantees supplied information on client education provided during four main steps of the weatherization process – intake, audit, weatherization, inspection – and possibly during a separate client energy education visit. The Subgrantees described the topics typically covered and materials given to weatherization clients for each of the five types of client education touches just listed.

Table 4.6 presents the average change in the core six energy conservation behaviors if client education was offered by their Subgrantee for each of the five types of "touches". From these results, it is evident that a separate client education visit has the most substantial, and the only statistically significant, impact on client energy conservation behaviors.

Table 4.6 Client Energy Conservation Behaviors by Client Education Touches Pre- to Post-Weatherization

Client Education Offered During _____	Yes	No	Change
Intake	.19	-.14	.33
Audit	.04	.25	-.21
Weatherization	.00	.23	-.23
Separate Client Ed Visit	.77	-.17	.94*
Inspections	.06	.00	.06

*** p<.001; ** p <.01; * p<.05

Table 4.7 presents correlation coefficients between the change in behaviors post-weatherization with the number of energy topics covered during each touch (ranges from 0-4), the total number of energy education touches a household receives from their Subgrantee (0-5), the total number of topics covered

[26] See Tonn, Rose and Hawkins (2015) for a description of the survey and descriptive statistics on client education offered in PY 2010 by the Subgrantees.

(0-20), and the total number of educational materials left with the households (0-20). Again, the only statistically significant influence on client energy conservation behavior is the number of topics covered in a separate energy education visit. The next highest correlation is with the total number of times during the weatherization process a Subgrantee offered client education, but this correlation is not statistically significant.

Table 4.7 Client Energy Conservation Behavior Changes Correlated with Client Education Descriptors (by Correlation Coefficients)

All Six Types of Energy Behavior Change	During Intake (# of energy topics)	During Audit (# of energy topics)	During WX (# of energy topics)	During Inspection (# of energy topics)	During Separate Visit (# of energy topics)	Total # of Topics Covered	Total # of Touches	Total # of Materials
	.102	-0.075	-.066	-.084	.322*	-.054	.166	.116

*** p<.001; ** p <.01; * p<.05

The next set of analyses explores the potential impacts upon specific energy conservation behaviors of client education targeted specifically at those behaviors. For example, what might be the impact of client education on windows with respect to whether or not households use cross ventilation to help cool their homes in the summer? To explore the answer to this question, households were placed in four categories: did not use cross ventilation pre- or post-weatherization; used pre- weatherization but not post-wx; did not use pre-weatherization but did post-wx; and used cross-ventilation both pre- and post-weatherization. One could argue that client education on a specific topic has an impact on a specific energy conservation behavior if it was found that relatively more households moved from not exhibiting to exhibiting the behavior post-weatherization (right direction) and relatively fewer households moved from exhibiting the behavior pre-weatherization to not exhibiting the behavior post-weatherization (wrong direction).

For example, with respect to cross ventilation, the total number of households in each category (see Table 4.8) and the percentages of homes moving in each direction (see Figure 4.8) suggest that at least this specific client education topic had a positive impact. In other words, fewer households that received the windows client education moved in the wrong direction and more moved in the right direction. Specifically:

8 of 19 households (42%) that ***did not*** receive client education on windows moved from practicing cross-ventilation pre-weatherization to not practicing cross-ventilation post-weatherization (wrong direction)

Versus

10 of 43 households (23%) that ***did*** receive client education on windows moved from practicing cross-ventilation pre-weatherization to not practicing cross-ventilation post-weatherization (wrong direction)

Versus

8 of 48 households (17%) that ***did not*** receive client education on windows moved from not practicing cross-ventilation pre-weatherization to practicing cross-ventilation post-weatherization (right direction)

Versus

23 of 87 households (26%) that ***did*** receive client education on windows moved from not practicing cross-ventilation pre-weatherization to practicing cross-ventilation post-weatherization (right direction)

On balance, these patterns of behavior are not found with respect to the other five client education topic – energy conservation behavior pairs included in Table 4.8 and Figure 4.8. In each of the remaining five cases, the recidivism rate is about the same (e.g., 19% to 23% of households moved from purchasing CFLs pre- weatherization to not purchasing CFLs post-weatherization (wrong direction) for the no client education and client education groups, respectively). Movement towards the desired energy conservation

behaviors is actually higher as a percentage of homes in four of the five cases that did not receive client education on specific topics (e.g., 75% to 51% of households moved from not purchasing CFLs pre-weatherization to purchasing CFLs post-wx (right direction) for the no client education and client education groups, respectively). Thus, overall, with the exception of separate client education visits, the specific client education provided and described by the Subgrantees did not have appreciable impacts on energy conservation behavior.

Table 4.8 Energy Conservation Behavior Pre- and Post-Weatherization by Whether Client Education Was Provided for Specific Topic (number of households)

Energy Conservation Behavior		Client Education Offered on Topic		
Cross Ventilation Used		***Client Ed Covered Windows***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
No	No	40	64	104
Yes	No	8	10	18
No	Yes	8	23	31
Yes	Yes	11	33	44
Never Open Windows Summer		***Client Ed Covered Windows***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
Disagree	Disagree	95	182	277
Agree	Disagree	11	24	35
Disagree	Agree	3	15	18
Agree	Agree	7	15	22
Never Open Windows Winter		***Client Ed Covered Windows***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
Disagree	Disagree	30	62	92
Agree	Disagree	39	93	132
Disagree	Agree	5	11	16
Agree	Agree	1	70	112
Never Leave Lights On in Unoccupied Rooms		***Client Ed Cover Lighting***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
Agree	Agree	43	173	216
Disagree	Agree	8	55	63
Agree	Disagree	4	22	26
Disagree	Disagree	9	38	47
Purchase CFLs		***Client Ed Covered Lighting***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
No	No	3	23	26
Yes	No	4	24	28
No	Yes	9	24	33
Yes	Yes	17	81	98
Purchase Energy Star Products		***Client Ed Cover Energy Star***		
Pre-Wx	**Post-Wx**	**No**	**Yes**	**Total**
No	No	12	9	21
Yes	No	3	2	5
No	Yes	12	18	30
Yes	Yes	31	35	66

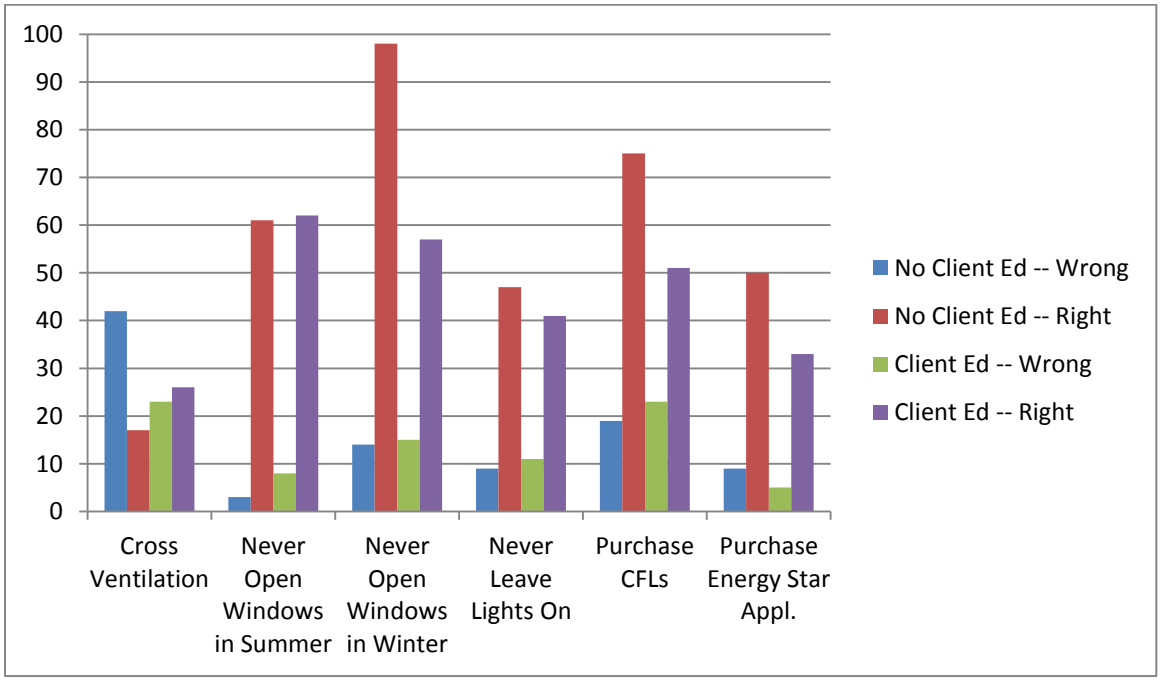

Figure 4.8 Energy Conservation Behavior Changes Post-Weatherization and Client Education (by Percent of Households)

4.3 USE AND KNOWLEDGE OF THERMOSTATS

The national occupant survey contained numerous questions about thermostat use. This subsection summarizes important findings from these questions. Post-weatherization, one would like to find that the number of programmable thermostats present in homes increased and that they are being used effectively. The results presented in Figure 4.9 support the first but not the second point. The number of treatment group households that had programmable thermostats increased from 27% to 43% post-weatherization. Unfortunately, the percentage of households that programmed their thermostats, for three or four uses, actually decreased slightly post-weatherization. The number of households that never reprogram their thermostats increased from 30% to 37% and never override their thermostats increased from 48% to 59%. Rates of using the hold function decreased somewhat post-weatherization, from 64% to 60%. These results suggest that households are not taking full advantage of their programmable thermostats nor altering thermostat settings to deal with seasonal to daily changes in weather, occupancy or other conditions. This is despite 86% of Subgrantees reporting that they provided specific client education on thermostat management.[27]

[27] See Tonn, Rose, and Hawkins 2015.

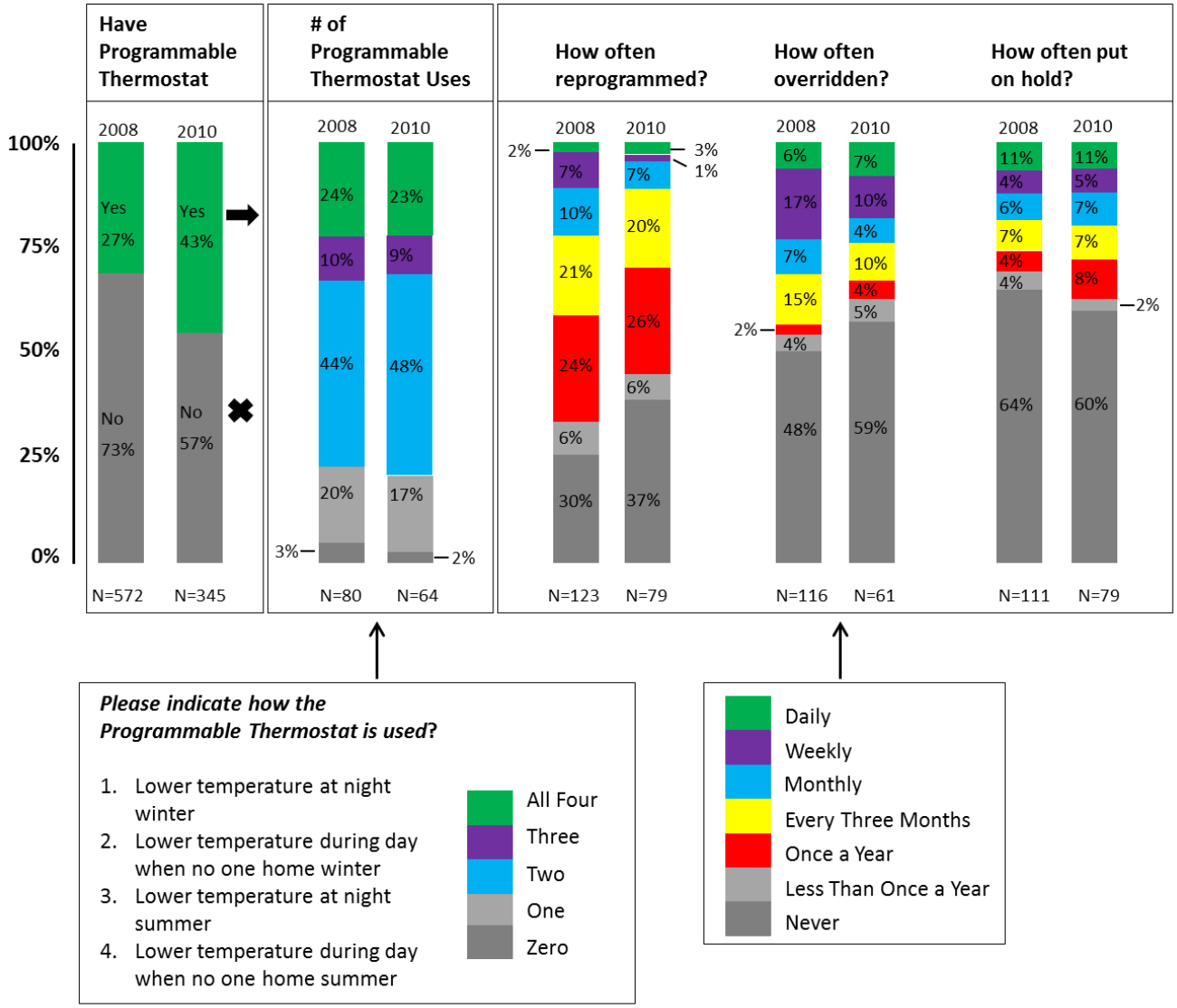

Figure 4.9 Uses of Programmable Thermostats Pre- and Post-Weatherization

Several additional questions were asked about thermostat use. The overwhelming majority of households, 89%, reported post-weatherization that someone in their home does know how to use the programmable thermostat (See Figure 4.10). However, more homes reported that their thermostats were not programmed post-weatherization (increased from 34% to 39%) despite a relative increase in households' perception about the ease-of-use of their programmable thermostats (the percentage of household reporting that their thermostats were somewhat to very easy to use increased from 80% to 85% post-weatherization) and most households reporting that no thermostat features need improving (60% post-weatherization versus 45% pre-weatherization).

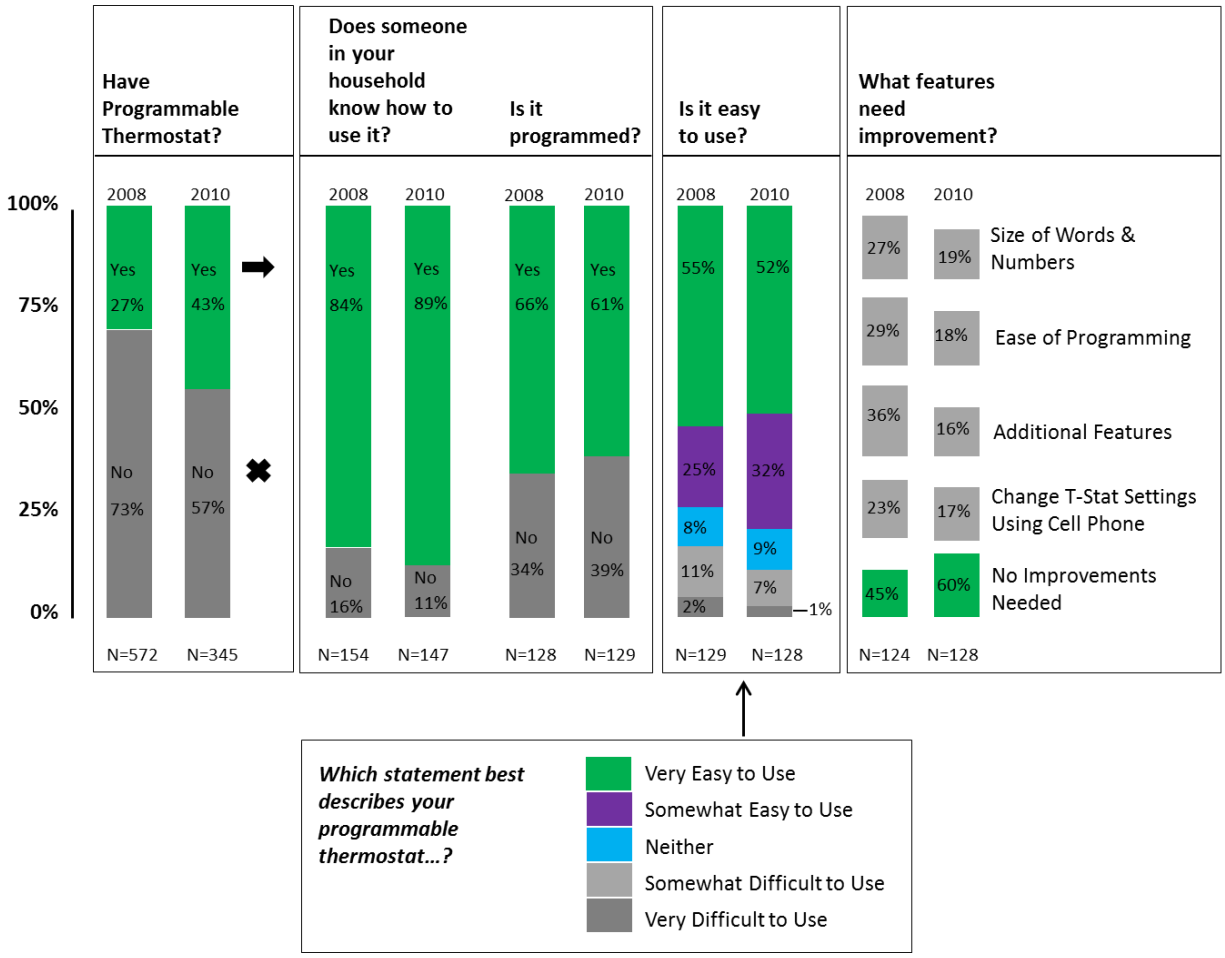

Figure 4.10 Usage of Programmable Thermostats Pre- and Post-Weatherization

The results presented in Figure 4.11 explore relationships between using the setback capabilities of programmable thermostats, nighttime thermostat settings in winter and summer, and households' self-reports on how difficult it is to pay energy bills due to finances. One would expect to see higher setback rates post-weatherization, lower winter and higher summer nighttime thermostat settings for homes using their setback features, and less hardships in paying energy bills suffered by those using the setback features of their programmable thermostats. Once again, the results are mixed with respect to expectations.

With respect to the first point, the setback rates for the treatment group did not increase post-weatherization, though the setback rate for the comparison group homes did increase 7% from one year to two years post-weatherization. In every case, the homes using the setback capability reported lower nighttime thermostat settings. In only two of the four cases (treatment pre-wx and comparison 1-year post-wx) were the nighttime settings in summer higher in the setback homes.

The strongest result with respect to hardships encountered while paying energy bills is the treatment group, pre-weatherization case. Over 25% more of the "no setback households" found it very hard to pay their energy bills than the "setback households." Fewer no setback households had trouble paying energy bills post-weatherization than setback homes. This second relationship describes the results for the comparison group one-year post-weatherization, but two years post-weatherization the non-setback

homes have more problems paying energy bills. From the last three sets of results, it is hard to disentangle setback rates, thermostat settings, and difficulties in paying energy bills.

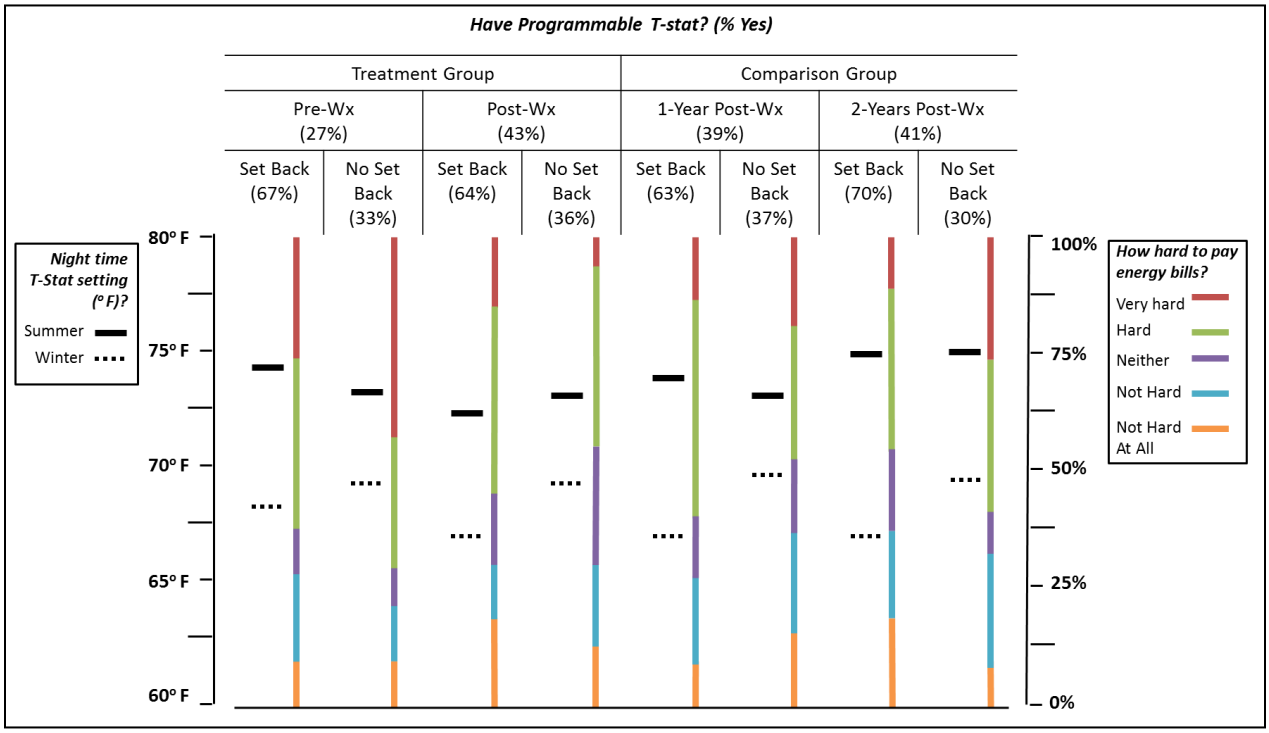

Figure 4.11 Use of Programmable Thermostat Set-Back Function Pre- and Post-Weatherization by Indoor Temperature Settings and Ability to Pay Energy Bills

One explanation for these confusing results is that by-and-large the respondents do not have a strong understanding about how thermostats work. Table 4.9 presents results from four questions gauging occupants' understanding of thermostats. For example, respondents were asked to rank whether this statement about thermostats was true or false: *If a thermostat is turned up very high, the homes gets warmer faster*. This IS a false statement, though 36% of treatment group households indicated this statement was true pre-weatherization and even a higher percentage (40%) indicated it was true post-weatherization. These percentages are approximately the same for the comparison group one-year and two-years post-weatherization. Over 80% of households incorrectly believe that the thermostat controls the temperature of the air coming from the heating/and cooling unit and the majority incorrectly believe that if the thermostat is turned down at night or when no one is home, more energy is used. The only question that the respondents correctly answered (at over 80%) is that the thermostat only senses temperature in the room where the thermostat is located.

Table 4.9 Knowledge about Thermostats (%)

	Treatment		Comparison	
	Pre-Wx	Post-Wx	1-Year Post	2-Years Post
If thermostat is turned up very high, home gets warmer faster	36%	40%	39%	41%
Thermostat controls temperature of air coming from heating/cooling unit	86%	86%	84%	82%
Thermostat only senses temperature in room where thermostat is located	82%	82%	81%	84%
If turned down at night/when no one is home, more energy used than saved	53%	52%	53%	55%

The last set of results ties together the budget issues analyses presented in Sect. 3.0 with the thermostat focus of this subsection. Specifically, knowledge about thermostats is examined within the context of the household budget issue clusters. Two competing hypotheses are put forward: 1) households in the Worst Case budget issues category might find themselves in that category in part because they do not understand how thermostats work and therefore expend more money on energy than they otherwise might; or 2) that these households by virtue of the budget pressures they face end up knowing more about thermostats than their counterparts in the other clusters.

Following the pattern established above, the results presented in Table 4.10 are mixed. The second hypothesis is strongly supported when the Worst Case and Best Case households are compared over two statements (turn thermostat up, home gets warmer faster and if turned down, more energy is used than saved). Overall, the Best Case household respondents are not distinguished by their knowledge of thermostat systems. The utility bill challenged cluster is relatively more knowledgeable except with respect to thermostat behavior when no one is home. The food issues cluster exhibits an inconsistent grasp of thermostat behavior, understanding that turning up the thermostat does not get the home warmer faster but then not understanding that thermostats do not control the temperature of the air coming from the unit.

Table 4.10 Thermostat Knowledge by Budget Issue Clusters

Cluster Number Budget Clusters		If thermostat turned up very high in winter, home gets warmer faster	Thermostat controls temp of air coming from heating/cooling unit	Thermostat only senses temperature in room where thermostat located	If turned down at night/no one home, more energy used than saved
1 Food & Medical Issues	Mean	.35	.86	.80	.51
2 Worst Case	Mean	.32	.83	.77	.29
3 Food Issues	Mean	.25	.94	.75	.50
4 Pervasive Bill Trade-off Issues	Mean	.50	.89	.89	.50
5 Best Case	Mean	.43	.87	.81	.57
6 Utility Bill Issues	Mean	.31	.82	.90	.53
Total	Mean	.39	.87	.82	.52

5. CONCLUSIONS

This report explores in more depth data collected through the National Occupant Survey administered as part of the evaluation of DOE's Weatherization Assistance Program (WAP). This report complements other reports that presented basic statistics from the first administration of the survey (Carroll et al. 2014) and assessed the health and household benefits of WAP (Tonn, Rose, and Hawkins 2014). Three topics were addressed by this report: budget issues faced by WAP recipient households; energy conservation behaviors; and use of programmable thermostats.

WAP recipients can be characterized by the number of budget issues they face. Approximately 10% of households reported experiencing at least eight of ten serious budget issues. Another 13% experienced about six in ten issues. Conversely, almost half of the recipients experienced less than one in ten of the issues. The households that faced more budget challenges also faced more challenges with respect to other health and home conditions than households that experienced few budget issues. The former experienced more flu, colds, and thermal stress events, and their homes had significantly more issues with respect to odors, mold, and infestations. Overall, households that are larger, live in larger homes, have lower incomes, and are of working age experience more budget problems. These homes showed the most improvement post-weatherization across a large number of variables, though these households were still worse off than most that received weatherization.

The results suggest that the weatherization process did not have significant impacts on household energy conservation behavior. For example, about the same number of households washed and dried their clothes with full loads (approximately 80% and 76%, respectively) pre- and post-weatherization. Rates for unplugging appliances (~27%) and hanging clothes out to dry (~37%) were also about the same. In a few cases, energy conservation behaviors increased post-weatherization (e.g., treatment homes purchasing Energy Star appliances increased from 60% pre-weatherization to 76% post-weatherization). In about an equal number of cases, energy conservation behavior decreased (e.g., 73% of comparison group homes purchased CFLs pre-weatherization, dropping to 64% post-weatherization). Thermostat settings also showed little change post-weatherization.

On the other hand, on average, the percentage of households that heated or cooled all of the rooms in their homes increased post-weatherization regardless of the number of rooms in the home or climate zone. Weatherization did not appear to impact the use of cross ventilation or methods to reduce heat gain in the summer (e.g., closing drapes). Window use in the summer appeared not to change although more homes reported opening windows during the winter season.

Similar to the budget issue analysis, households can be clustered by their energy conservation behaviors. About 25% of the households exhibit less than 2 energy conservation behaviors (out of a core of six potential behaviors), whereas only 11% exhibit more than 4 (4.6 on average). Unlike the budget issue analysis, household energy conservation behaviors appear to be idiosyncratic. Very few independent variables correlate with energy conservation behaviors, but the study did find that poor mental health and larger households are both negatively correlated with energy conservation behaviors. Patterns of energy conservation behaviors associated with each of the clusters seem to defy explanation.

From most viewpoints, client education has little to no impact on energy conservation behaviors post-weatherization.[28] The number of client education touches (e.g., at time of the audit, at final inspection), the number of topics covered per touch, and the number of client education items given households were all insignificantly correlated with changes in energy conservation behaviors. Households that received

[28] This is consistent with in-field observations of client education summarized in Berger et al. (2014) that client education was often offered only in a perfunctory fashion.

specific client education on topics that related to specific energy conservation behaviors did no better than households that did not receive such client education. The only significant relationship found was that separate client education visits had a positive and statistically significant impact on energy conservation behavior post-weatherization.

Use of thermostats is important with respect to household energy consumption. It was reported above that thermostat settings did not change much pre- to post-weatherization. It was also found that the use of programmable thermostats did not change appreciably post-weatherization. Households did not make use of the full capabilities of their programmable thermostats. Fewer households programmed, reprogrammed or overrode their programmable thermostats post-weatherization, suggesting that these devices faded into the background in a sizable number of homes post-weatherization. Recipients' knowledge about thermostat operation is also deficient, as most households incorrectly answered three of four basic questions about thermostat systems.

Overall, these results support two general conclusions. One, focusing weatherization on the 10-25% of households that suffer the most budget issues could yield the highest marginal returns with respect to health- and household-related non-energy benefits. Future research is needed to provide insights about what percentage of these weatherization households are also considered super-utilizers of medical services. Future research is also needed to determine whether households that could most benefit from weatherization from a health perspective are also homes that have the highest potential energy savings.

The second general conclusion is that there is ample space to improve the impacts of client education. The results suggest that separate client education visits are the most effective in changing energy conservation behaviors. Future research is needed to assess the benefits versus costs with respect to expanding this intensive type of client education.

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APPENDIX A. OCCUPANT SURVEY IMPLEMENTATION

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A.1 METHODOLOGY

The Occupant Survey is a three-part survey that was conducted with the selected WAP clients. (1) The Baseline Survey documents status and needs of clients prior to weatherization. (2) The Satisfaction Survey collects information on client perceptions of WAP service delivery. (3) The Follow-Up Survey directly measures how the status and needs of clients have changed one year after receiving WAP services.

The survey procedures included the following:

- Agency Sample – A sample of 220 service delivery agencies was selected to represent the 905 WAP service agencies nationwide.

- Treatment Group Sample – Each agency was asked to furnish a list of clients who were income-qualified for the program and scheduled for WAP audit.

- Comparison Group Sample – Each agency was asked to furnish a list of clients who had received WAP services one program year earlier.

- Interviews – Sampled treatment and comparison group clients were contacted and interviewed using a survey instrument designed by the Evaluation Team.

Interviews were completed with 1,094 treatment group clients and 803 comparison group clients. The subsequent Client Satisfaction Survey determined that 665 of the treatment group clients received WAP services, continued to live in the weatherized housing unit, and could be contacted for follow-up interviews. That group of 665 households serves as the treatment group population because they are most comparable to the comparison group that was served in 2010 and could still can be reached for interview. Among the 1,094 treatment group clients surveyed prior to receiving a WAP audit, 290 reported that they had not received WAP services and 139 could no longer be reached by telephone.

A.2 ANALYSIS FRAMEWORK

The purpose of the Occupant Surveys is to furnish information on the energy status and needs of applicant households and to assess the extent to which the WAP program is able to address those needs. The primary analysis sample for the study is the treatment group: households that have applied for the WAP program, have been determined to be income qualified for the program, and were scheduled for a WAP home energy audit. This study is designed to:

- Develop an understanding of client energy status and needs prior to any significant contact with the program,

- Determine whether the WAP program was able to deliver services to clients who were income-eligible for the program,

- Assess client perceptions of the effectiveness of the WAP program in meeting their needs, and

- Measure the change in status and needs of the client household after having received WAP services.

The three surveys contribute to this analysis in the following way

- Baseline Survey – The Baseline Survey was conducted with WAP clients prior to their home energy audit. While clients may have had some engagement with the WAP program by applying

- for program services, these interviews represent, as much as possible, the needs of the applicant households prior to receiving services from the WAP program.

- Service Delivery/Satisfaction Survey – The Satisfaction Survey was conducted in two rounds. The first round was conducted three months after the client's scheduled audit and asked clients whether they had received WAP services and, if so, to answer the Satisfaction Survey questions. The second round was conducted nine months after the scheduled audit; clients who had not yet received services at three months were re-contacted to determine whether services had been delivered and, if so, to answer the Satisfaction Survey questions.

- Follow-Up Survey – The Follow-Up Survey was conducted in the summer of 2013. The survey will be conducted with all treatment group households, including those that were served and those that were deferred.

The Baseline Survey documents client status and needs prior to weatherization. The Service Delivery/Satisfaction Survey documents which households were served and assesses client satisfaction with program services. The Follow-Up Survey assesses how client status and needs have changed for those clients who received WAP services, and how client status and needs have changed for clients who did not receive services.

One important component of the research design is that a comparison group of WAP clients was interviewed. The treatment group households were scheduled to receive WAP services during PY 2011. A comparison group of households that received services during PY 2010 also was sampled and interviewed. The primary purpose of the comparison group is to furnish a "difference of differences" analysis. In such a design, the gross program impact is the change in the treatment group status. But, the net program impact is determined by measuring the status change for a comparison group and netting out any change for the comparison group against the change for the treatment group to control for other unobserved factors. For example, if the treatment group had a 25 percent reduction in service terminations, but over the same time period the comparison group had a 10 percent reduction in service terminations that was a result of increased availability of LIHEAP funds, the net change in service termination levels due to the program would be estimated to be 15 percent (i.e., the observed change minus change that the treatment group might have experienced even without the program).

A.3 BASELINE SURVEY ANALYSIS

The primary purpose of the Baseline Survey report is to furnish statistics that document the status and needs of WAP clients prior to the receipt of program services. However, a cross-sectional analysis that compares treatment group clients to comparison group clients also furnishes valuable information on the potential impact of the WAP program. Both analyses are presented in this report; baseline statistics for treatment group households and analysis of similarities and differences with comparison group households.

One important pre-condition for this analysis is to ensure comparability of the treatment group and comparison group households. The treatment and comparison group households were sampled from the same agencies and interviews were conducted in the same way. However, there are certain factors that

could have affected the comparability of the client groups. Tables A.1 through A.3 furnish some key statistics for the treatment and comparison group households that help to assess their comparability. Table A.1 shows the distribution of clients by Climate Zone. A higher proportion of the treatment group clients were in the Cold Climate Zone; a larger proportion of comparison group households were in the Moderate and Hot Climate Zones. Similarly, Table A.2 shows that a higher percentage of the treatment group households were in the Northeast and Midwest Census Regions, while a higher percentage of the comparison group households were in the South Census Region. In terms of demographics and housing unit characteristics, the groups are similar in most respects. However, the treatment group has a larger

proportion of households with children (five percentage points) and the comparison group has a larger proportion of households with an elderly person (eight percentage points). For that reason, the comparative cross-sectional analysis is not viewed as being as robust as the longer-term longitudinal analysis. However, the distributions are sufficiently similar that they can be a useful leading indicator of the expected program impacts.

Table A.1. WAP Clients by Climate Zone

Climate Zone	Treatment	Comparison
Number of Respondents	665	803
Very Cold	26%	26%
Cold	48%	41%
Moderate	17%	22%
Hot	9%	11%
TOTAL	100%	100%

Table A.2. WAP Clients by Census Region

Census Region	Treatment	Comparison
Number of Respondents	665	803
Northeast	29%	25%
Midwest	39%	36%
South	19%	23%
West	13%	15%
TOTAL	100%	100%

Table A.3. WAP Clients by Demographics and Housing Unit Characteristics

Demographics	Treatment	Comparison
Number of Respondents	665	803
Single Family Home	76%	79%
Natural Gas Main Heat	52%	51%
Central Heating System	70%	71%
Home Owner	87%	91%
At least one Elderly Person	47%	55%
At least one Child	35%	30%
Employed	34%	32%

A.4 DATA COLLECTION STATISTICS

The Baseline Occupant Survey used sample development and interviewing procedures that were designed to achieve the highest possible response rate.

The agency contacts were made by Energy Center of Wisconsin (ECW)[29] case managers who have been working with service delivery agencies since 2010 to facilitate data collection for the overall evaluation project. For each sampled service delivery agency:

- Advance Mailing – The ECW case manager mailed information to the agency contact explaining the purpose of the data collection and the procedures for selecting and delivering client lists.
- Agency Phone Contact – The ECW case manager contacted the agency contact to discuss the data collection schedule and to clarify the study procedures.
- Agency Follow-Up – The ECW case manager conducted regular follow-up with the agency contact to facilitate the development and delivery of the clients lists.

Of the 220 sampled agencies, 204 (93%) furnished client lists. The survey was successful in getting completed interviews from 203 of the 204 agencies that furnished client lists.

The telephone interviews were conducted by Braun Research. The following contact protocol was used:

- Advance Mailing – APPRISE prepared and mailed advance letters to all sampled clients. These advance letters explained the purpose of the study, alerted the respondent that a $20 incentive would be paid, and gave the client an 800 number that they could use to contact the phone center if they preferred.
- Contact and Screen – Braun Research made 10 contacts to all numbers, ensuring that the time of day and day of the week was properly rotated. The interviewers left messages on answering machines every third call to alert the client of the purpose of the call.
- Spanish Language Interviews – When the telephone center encountered Hispanic households with a language barrier, an APPRISE interviewer re-contacted the households and conducted the interview in Spanish.

The survey contact rate was 83 percent, the cooperation rate was 88 percent, and the final response rate

[29] Oak Ridge National Laboratory issued subcontract to APPRISE, Inc. to assist with various evaluation tasks. In turn, APPRISE subcontracted several tasks to the Energy Center of Wisconsin.