Healthy Home Assessment for Immigrant and Non-immigrant Households in Rental Units in Minnesota

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Chapter One. Introduction

In 2005, more immigrants came to live in the state of Minnesota than in any of the preceding 25 years. The Department of Homeland Security reported the 2005 Minnesota immigration number as 15,456 people (U.S. Department of Homeland Security, 2006). Two of every five immigrants settling in Minnesota in 2005 came from Africa; the majority from Somalia. According to an immigration specialist with the Minnesota State Demographers' office, "If you include children born here, it (the African-born population) may have doubled already in this decade. The share of all Minnesota births that are to Somali mothers is becoming incredible" (Peterson, 2007).

Estimates of the number of Somali people living in Minnesota as early as 2002 ranged from 25,000 to 60,000 (League of Women Voters, 2002). Many of the Somali families were large and finding adequately-sized, affordable, quality rental properties was difficult. Furthermore, as followers of Islam, Somali men and women are not allowed to interact together outside of the home resulting in many women spending much of their time inside with curtains drawn to protect them from view (League of Women Voters, 2002; Minneapolis Foundation, 2004).

Housing units where windows are not opened often lacked adequate ventilation resulting in high humidity inside the home. Both inadequate ventilation and excess moisture potentially caused indoor air quality problems, especially in apartments where several people were present much of the day and night. It is generally accepted that people spent about 90% of their time indoors and about half of their time in their homes (Nazzaroff & Weschler, 2001; U.S. Department of Housing and Urban Development, n.d.).

Somali immigrants may spend large portions of their time inside their homes. The combination of limited housing options and multiple individuals inhabiting these mostly closed units for a high proportion of time generated concerns about the quality of the indoor environment for Somali immigrants. This concern motivated the development of this research and, specifically, exploration of the indoor air quality of immigrant Somali families living in multifamily apartment buildings in Minneapolis, Minnesota. The research data were collected in the early spring of 2008 from rental units of Somali and non-Somali families in an inner-city neighborhood in Minneapolis, Minnesota.

While the focus of the research was primarily on Somali immigrant families, the three buildings selected for this research were populated by families of a variety of nationalities, including non-immigrants. In an effort not to discriminate, all residents were invited to participate in this research. The result was that half of participants were Somali immigrants and half were non-Somali immigrants.

According to research conducted by social scientists, building scientists, and health professionals, poor indoor air quality is correlated with certain illnesses, especially respiratory illnesses, as well as a sense of well-being of occupants (American Lung Association [ALA] 2007; Mudarri & Fisk, 2007; Oie, Nafstad, Botte, Magnus & Jaakkola, 1999; Selgrade, et al. 2006; Sharma et al. 2007). Immigrant families living in the United States have a particular challenge because of cultural differences and a lack of understanding of how buildings should be maintained in cold climates (American Lung Association, 2007). The lack of control of moisture in buildings can also lead to building deterioration. Such deterioration can lead to additional indoor air quality problems such as the growth of mold and mildew (Gunnbjornsdottir et al. 2006; Health Canada, 2007).

Illnesses and health conditions caused by conditions related to high relative humidity in living quarters can be debilitating and lead to poor performance of children and adults in school and work. Mold can result from high relative humidity and moisture in living spaces (Gunnbjornsdottir et al. 2006; Health Canada, 2007). The lack of fresh air and adequate ventilation may produce similar results (U.S. Environmental Protection Agency [EPA],).

The Role of Education

Although there is limited published evidence that education on indoor air quality can be effective in reducing the incidence of health problems, there is research suggesting that education is important and can be an effective strategy to reduce indoor air pollutants. Corrin, Olson, Barber, Bode & Clark (1997) identified Hmong and Cambodian communities in Minnesota as being at particular risk from indoor environmental hazards because of language barriers, the lack of recognition of potential problems, and the lack of knowledge about how to access good information about indoor air quality. Corrin and colleagues designed and implemented a dual-language, culturally-appropriate educational program that was delivered by peer community teachers. Written and verbal assessment from community members and the peer community teachers concluded that this education was effective and well-accepted by the immigrant communities.

Unfortunately, many families, both immigrant and non-immigrant, subscribe to a “just-in-time” philosophy of home maintenance. Proactive preventative maintenance of a home is likely to avoid major health problems. Small (2003), and Selgrade et al. (2006) suggest that educating the public and building inspectors will lead to identification of problems of indoor air quality and promote the reduction of sources of health problems. Warsco and Lindsey (2003) suggested that keeping people healthy depends on attention to the interaction of a building and its occupants. Educating occupants about their indoor environment is one way to address this relationship.

Teaching families how to maintain their living spaces to improve their indoor air quality is important if individual family members are to reach full potential in school and work settings. Poor indoor air quality is often the cause of respiratory illness. Respiratory illness in children can lead to life-long chronic disease (Burr et al, 1999). Immigrant families may be at higher risk for some health problems due to the lack of education about maintaining good indoor air quality (Corrin et al. 1997).

The basis of this research was the completion of a questionnaire by both a subject (intervention) group and a control group, each consisting of twelve heads of households. The questionnaire was delivered to both groups prior to the intervention training and before any measuring equipment was installed in the dwelling units. After the questionnaires were completed, the intervention group received the training. Indoor air quality was measured by temperature and relative humidity in each participant residence, and carbon dioxide and select total volatile organic compounds in a subset of the participant dwellings for both groups. These benchmarks have been indicated by research to indicate potential problems for occupants (Arif & Shuh, 2007; Emenius et al. 2003; Fanger, 2006; Jones, 1999; Wolkoff, 1997). An adult member of each household was asked to complete both the pre- and post-intervention questionnaire.

The indoor air quality training developed for this research was based primarily on the U.S. Housing and Urban Development (HUD) publication *Help Yourself to a Healthy Home* published jointly by HUD, the Environmental Protection Agency, and the University of Wisconsin Extension Service (U.S. HUD, n.d.). A second source for material for this training was the RentWise program designed for renters. This training had been adapted from the University of Wisconsin Extension program by Minnesota (Bruin, 2004). The RentWise training has eight modules. One of these modules, Taking Care of Your Home, was revised by the researcher for purposes of this study to focus on information and training on maintaining good indoor air quality.

Hypotheses

There are three hypotheses addressed in this research. The first hypothesis is that training and education on indoor air quality will improve the indoor air quality in multifamily apartments occupied by immigrant and non-immigrant families in Minneapolis. The null hypothesis, that training and education will not improve the indoor air quality in multifamily apartments occupied by immigrant families in Minneapolis, would be rejected if measurements of indoor air of the intervention and control groups show improvement approximately two months after the family member completes a three hour training on Indoor Air Quality.

The second hypothesis is that the Indoor Air Quality intervention training will change occupant behaviors that affect indoor air quality. Approximately two months after completing the Indoor Air Quality intervention, participants were asked to complete a second questionnaire that was identical to the first questionnaire. Results were compared to determine if there were significant differences in how residents reported behaviors with, for example, the use of bath fans, smoking in their apartments, etc., after the indoor air quality educational intervention. The null hypothesis, that the Indoor Air Quality training does not change occupant behaviors, will be rejected if there is a statistical significance difference at the .05 level between the intervention group that received the training and the control group.

The third hypothesis addressed the theory used for the research. This theory, known as Andragogy, is an adult learning theory. The hypothesis was that attending the Indoor Air Quality training will change occupant perception of learning about air quality in their homes. The null hypothesis, that attending the Indoor Air Quality training will not change occupant perception of learning about air quality in their homes, will be rejected if there is a significant statistical difference at the .05 level between the intervention and the control group. To test this hypothesis, 13 of the 36 questions on the questionnaires were based on the participants' knowledge and feelings about the air in their apartments and on their perceptions of learning about how to affect the air inside their dwellings.

In the next chapter, a review of research relevant to these hypotheses is presented.

Chapter Two. Literature Review

This literature review addresses health problems that renters may encounter if their dwellings have poor indoor air quality and reviews recommended methods of controlling selected pollutants that may impact indoor air quality. A discussion of the theory that was used to organize this research, Andragogy, concludes the chapter.

An incongruous situation that has led to a decrease in the quality of indoor air is the prevalence of energy efficient construction without provision for adequate ventilation. A tighter and more efficient building has lowered the cost for heating and cooling. Unfortunately, it has, in some instances reduced ventilation, promoting the buildup of conditions such as moisture and high relative humidity. Another concern is an elevated level of volatile organic compounds which may be emitted from paints, varnishes, particle board, cleaning products, building materials and many other products used in building construction and maintenance (Jones, 1999). Emenius et al. (2003) found that newer apartment buildings and single-family homes with crawl spaces and a concrete slab equipped with exhaust ventilation were associated with an increase of recurrent wheezing in infants. They also noted a correlation between the low air changes per hour and absolute indoor humidity. Children in these homes have a much greater risk of recurrent wheezing and other respiratory problems.

Health and Pollutants

Moisture and Mold

According to the Canadian Mortgage and Housing Corporation (CMHC), there are several factors that can lead to poor indoor air quality and an unhealthy indoor environment in living spaces. They include a lack of adequate ventilation, high relative humidity, and water infiltration or leaks (Canada Mortgage and Housing Corporation, 2007). All of these factors may be related to moisture problems.

Angell and Olson (1988) published a summary of research on moisture problems in homes that remains pertinent today. They suggested that controlling moisture in homes is dependent on both household conditions and household behavior. A reasonable conclusion is that research on moisture conditions in homes should include an inspection of house conditions such as possible combustion backdrafting and household produced moisture such as the presence of aquariums, excessive plants, the number of household members, and household cooking practices.

Researchers in the Scandinavian countries have traditionally been leaders in studies linking indoor dampness (relative humidity) and moisture to health affects. In particular, studies have shown a relationship between respiratory symptoms and indoor dampness (Ekstrand-Tobin, 1993; Gunnbjornsdottir et al, 2006; Melia et al, 1982; Waegemaekers, van Wageningen, Brunekreef, & Boleij, 1989). Research conducted by Spengler et al. (1994) used logistical regression to analyze data from North American homes of more than 15,000 children. The findings suggested that dampness, mold and water variables were associated with increased episodes of respiratory symptoms.

The RHINE (Research Health in Northern Europe) study (Gunnbjornsdottir et al., 2006) was typical of other studies and is a good example of the way moisture or mold and respiratory illness studies have been structured. Over 16,000 adult subjects from Iceland, Sweden, Denmark and Estonia took part in the study. Subjects self-reported conditions of exposure to moisture if any of the following were observed by subjects in their homes in the twelve months previous to the study: 1) water leakage or water damage indoors on floors, walls, or ceilings; 2) bubbles or yellow discoloration on plastic flooring or black discoloration on parquet flooring; or, 3) visible mold growth on walls, floors, or ceilings. Subjects also reported any of the following respiratory symptoms experienced over the twelve months previous to the study: 1) wheezing or whistling in the chest; 2) being woken by an attack of shortness of breath; 3) being woken by an attack of coughing; and, 4) usually bring up phlegm or have any problem in bringing up phlegm. Subjects reporting one or more of these symptoms were considered to have respiratory symptoms. As in many of the studies noted above, this study found that all four respiratory symptoms (and asthma) were significantly more prevalent in homes with indoor dampness using both a socioeconomic index and body mass index. The statistical analysis (Stat 5.0) included unadjusted logical regression comparing homes that were dry versus damp homes.

In more recent years, studies in North America have corroborated the outcomes of those in Northern Europe. (Fisk, Lei-Gomez & Mendell, 2007; Mundarri and Fisk, 2007; Sharma, et al., 2007.)

In 2002, the American College of Occupational and Environmental Medicine (ACOEM) issued an ACOEM Evidence-based Statement acknowledging that molds and other fungi may adversely affect human health in these three ways: infection, toxicity, and allergic reaction. The report contains important information about mycotoxins and infections, but clearly states “Current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotxins in the home, school, or office environment” (ACOEM, 2002, p. 7). The report also stated that while a number of fungi cause superficial infections (such as the common tinea pedis or Athlete's foot), most fungi are not pathogenic to healthy humans.

However, when referring to allergic reaction, the report acknowledged the growing body of evidence that respiratory illness, including wheezing, asthma, cough and phlegm production have been found to be significant in homes where moisture and mold are present. The ACOEM reported that homes where moisture is present may also have a high count of dust mites and bacteria, which may also lead to these same symptoms. It is significant that the first recommendation was that "individuals with allergic airway disease should take steps to minimize their exposure to molds and other airborne allergens, e.g., animal dander, dust mites and pollens" (ACOEM, 2002, p 3).

Just as there are studies showing a relationship between moisture in buildings and respiratory illness, there are studies specifically targeting mold and health symptoms. One of those studies was conducted in 1997 by Huang and Kimbrough. The two-year study compared the clinical symptoms of 44 children who had persistent cold-like symptoms with the mold count in their homes. The clinical scores correlated significantly with the mold count in the home. The conclusion of the study was to recommend that children with persistent cold-like symptoms should live in homes where humidity is controlled and efforts are made to remove mold from inside the homes.

Although ACOEM determined that "most fungi are not pathogenic to healthy humans" (2002), Stark, Burge, Ryan, Milton, & Gold (2003) conducted a study to help determine if the widely recognized relationship between illness of the lungs and bronchial tubes, known as lower respiratory illness (LRI), in infants and home dampness could be partially explained by the presence of fungi in their homes. LRI illnesses include croup, pneumonia, and bronchitis.

The homes of 505 infants with at least one parent with a history of asthma or allergy were tested for fungi. Researchers controlled for other potential predictors of LRI, including sex, presence of water damage, winter birth, visible mold or mildew, and breastfeeding. They reported a “strong relationship between high household fungal levels and an increased incidence of doctor-diagnosed LRI in the first year of life” (Stark et al., 2003, p. 231). The study also found that “exposure to high fungal levels can increase the risk of non-wheezing as well as wheezing LRI” (Stark et al., 2003, p. 236).

In 2004, the Institute of Medicine (IOM) of the National Academy of Sciences completed a critical review of research of the scientific literature on the association of dampness and mold in buildings with adverse health effects. The IOM concluded that “excessive indoor dampness is a public health problem” (Fisk et al., 2007, p 284). In 2007, Fisk et al. conducted a meta-analysis on the IOM studies plus other related studies. Weighing more heavily on large studies, Fisk et al. selected only original, refereed archival journal studies for inclusion in the meta-analysis for relevance, quality, and similarity. The meta-analysis used a statistical method of “central point estimates and confidence intervals of odds ratios that summarized the magnitude of increased risk of several health outcomes in buildings with dampness and mold” (Fisk et al., 2007, page 284). Health outcome categories included upper respiratory tract symptoms, cough, wheeze, a diagnosis of asthma, current asthma, or asthma development. Thirty-three studies qualified for inclusion. The meta-analysis suggested that building dampness and mold were associated with a 30 – 50% increase in a variety of health outcomes in a variety of populations. In all cases the associations were statistically significant. While Fisk and colleagues recognize their work does not specifically prove cause and effect, they suggested it strongly supports the IOM conclusion for a need to reduce dampness and mold in human dwellings.

In summary, scientific evidence that moisture and mold in buildings is associated with adverse health effects appears indisputable. In almost all cases, researchers suggest or recommend that action be taken to prevent and reduce building moisture.

Volatile Organic Compounds

Volatile organic compounds (VOCs) have been defined by the World Health Organization (1989), as organic compounds with boiling points between approximately 50 and 260 degrees Centigrade (122 degrees to 500 degrees Farenheit). Wolkoff (1997) note that this range of temperature was chosen for ease of sample measurement and not because of any evidence of human health response. The range defined by WHO means that many materials will off-gas (release) VOCs at typical temperatures both indoors and outdoors. The research of VOCs and human health response is not clear-cut. Common responses include eye irritation, odor annoyance, and airway irritation. However, responses are wide and have not been shown to be consistent across a distinct range of measured VOC levels.

VOCs are found in homes due to human activities in indoor spaces, building materials used in construction, furniture and other products brought into the house, and from VOCs in outdoor air that enter the house through infiltration. Often high levels of

VOCs are present when housing is new or when new materials are introduced into a living space. VOCs are also emitted from most paints and interior finishes. During initial off-gassing, VOC exposure may be significant and cause people to experience discomfort and some health related symptoms.

It is generally accepted by health professionals that pollutants, including volatile organic compounds, result in indoor air quality complaints and specific health effects such as asthma-like symptoms such as breathing difficulties (Arif & Shah, 2007; Norbaeck, Bjoernsson, Janson, Widstoem, and Boman, 1995). Other health effects include eye, nose and throat irritation, headaches, loss of coordination, nausea, and damage to liver, kidney, and central nervous system (U.S. Environmental Protection Agency, 2012). Unfortunately, any direct causation between many VOCs and a particular symptom cannot be explained with current research. It is recognized that some chemicals react at indoor conditions, leading to irritations in humans, such as airway, eye and nose irritations. Sometimes these irritations are severe. On the other hand, when what appears to be high levels of some VOCs are measured in indoor spaces, often no complaints are reported (Wolkoff & Neilson, 2001).

There has recently been a transition from using individual compound VOC measurements to the measurement of total volatile organic compounds (TVOCs) to define the perceived impact on indoor air quality. Wolkoff and Neilson (2001) addressed several relevant questions to determine if this approach is logical, reasonable and sufficient. In doing so, they cited a European working group, the European Collaborative Action ECA-IAQ (1997) who defined TVOCs as “a sum of VOC concentrations in $\mu g/m^3$ within the VOC chromatographic window” (Wolkoff &

Neilson, 2001, p 4409). However, ECA could not identify a clear cause-effect relationship between TVOC concentrations and health effects. Wolkoff and Neilson pointed out that the ECA definition may too narrowly define TVOCs and therefore fail to measure the effect of TVOCs on human health. Wolkoff and Neilson argue that the conclusion that TVOCs have no biological relevance is a fallacy. Furthermore, they appear to be convinced that TVOC measurement can be useful in quality control of indoor air environments, particularly where TVOC levels are high.

Microbiological VOCs, known as MVOCs are sometimes used in TVOC measurements, but according to Wolkoff & Nielsen (2001) and Pasanen, A., Korpi, Kasanen, & Pasanen, P. (1998), it is unlikely MVOCs result in airway irritation. However, they do not rule out the possibility that with better measurement tools, research may identify a relationship between MVOCs and airway irritation.

The types of VOCs measured have changed since the early 1990s due in part to two developments: 1) changes in sampling techniques; and 2) introduction of new building materials that may contain solvents that were not used in earlier construction (Reitzig, Mohr, Heinzow, & Knoppel, 1998). For instance, in 1996, Calogirou, Larsen, Brussol, Duane, and Kotzias, reported that some unsaturated VOCs may actually be underreported if they exist in ozone-enriched or environments containing high levels of nitrogen dioxide partly due to atmospheric reactions or reactions at the sorption medium. Rodes, Kamens, & Wiener (1991) suggested that concentrations of VOCs in breathing zones could be increased by up to four times due to new types of solvents.

In summary, while there are concerns and questions about VOC and TVOC testing and measurement, there is an adequate body of research suggesting that, when combined with other parameters, such testing is a reasonable approach to contribute to the assessment of the quality of the indoor environment of buildings.

Toluene, a volatile organic compound, is a colorless liquid with a distinct sweet smell. It is used to make many products, including paints, fingernail polish, adhesives, rubber, cleaning products, and shoe polish. It is also used as a solvent in nylon, plastic soda bottles, and cosmetic products. Building materials, especially those containing adhesives, can produce high levels of toluene inside buildings. Levels of toluene have been measured to have an average of 10.8 $\mu g/m^3$ in urban areas; 31.5 $\mu g/m^3$ in indoor air (U.S. EPA, 2012).

Because toluene is present is so many products used in building products and products found in the home such as cosmetics, fabric dyes, adhesives, paints, stain removers, rubber cement, carpets, upholstery fabrics, vinyl floors, composite wood products, air fresheners, and cleaning and disinfecting chemicals, it is sometimes used as a tracer for VOCs. It is also used because it is a VOC with known health problems. When inhaled, it can have an effect on the brain, causing headaches and impairment of the ability to think properly. High doses can damage kidneys; lower doses can cause drowsiness, nausea, reduced appetite, tiredness, and memory loss (U.S. Department of Health and Human Services, 2000). Low levels of exposure to toluene have also been shown by some studies to increase health problems, particularly in those with asthma and other respiratory illnesses (State of Minnesota Department of Health, 2010). Fishbein (1985) stated that "the narcotic and neurotoxic properties of Toluene represent the main recognized health hazards to humans."

According to the Minnesota Administrative Rule, 4717.8100 Table of Chronic HRVs (Health Risk Values), the endpoint of concern for toluene, which affects the nervous system and upper respiratory systems, is 400µg/m^3 (106.4ppm) (State of Minnesota Administrative Rules, 2009). The Occupational Safety and Health Administration (OSHA) sets a limit of 200ppm of toluene for air in the workplace, averaged for an 8-hour exposure per day over a 40-hour work week. According to the U.S. Department of Health and Human Services (2000), the National Institute for Occupational Safety and Health (NIOSH) "recommends that toluene in the workplace not exceed 100 ppm" as an average over 8 hours.

Carbon Dioxide

Carbon dioxide is a colorless, odorless gas that is produced when any carbon-based material is burned. Carbon dioxide is also produced by humans and animals during respiration. The level of carbon dioxide in an indoor environment depends on the number of people in the house, the operation of any carbon-based combustion equipment in use, the level of carbon dioxide in the outdoor air around the house, the time of day, and the amount of fresh air brought into the house at a given time (State of Minnesota Department of Health, 2007).

While a plethora of studies have been conducted on the relationship between moisture, mold, VOCs and adverse health affects, a much smaller number of studies have examined the influence of carbon dioxide on health. However, one such study was undertaken by Khalequzzaman et al. (2007) in Bangladesh to consider if fossil fuel should replace biomass fuel in a city where indoor air pollution appears to be worsening. Researchers focused on VOCs, carbon monoxide, carbon dioxide, nitrogen dioxide, and dust particles, relating those pollutants to the health of children under the age of five because of the physiological susceptibility which places young children in a high-risk category. Indoor air pollution is particularly significant for young children because their respiratory systems are not fully developed according to Banerjee (2000) as cited in Khalequzzaman et al. 2007. Although this study limited the discussion of carbon dioxide levels to the difference between levels when home cooking and heating was done with either fossil or biomass fuels, the concern of researchers about the levels of carbon dioxide in indoor air remains an important issue. In this case, as in others, the level of carbon dioxide can be an indicator of the amount of fresh air available inside the home assuming sources are relatively constant or well-characterized.

Although hazardous levels of carbon dioxide are generally not found in indoor environments, the measurement of carbon dioxide is often taken as a surrogate measure of the indoor air. If carbon dioxide levels are high inside a dwelling, it is assumed that outside air with assumed fewer pollutants should be introduced into the house. Therefore, carbon dioxide levels can indicate how well a ventilation system is working in a house. One reason carbon dioxide is used in this manner is because testing for carbon dioxide is relatively inexpensive and easy to do, depending on the environment.

There are no standards for residential indoor carbon dioxide levels. However, the American Industrial Hygiene Association (State of Minnesota Department of Health, 2007.) suggest that levels above 800 parts per million (ppm) will result in complaints about comfort levels from occupants. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommend an indoor carbon dioxide level of no more than 700ppm above ambient outdoor concentrations. (State of Minnesota Department of Health, 2007.)

Scientists are concerned that ambient carbon dioxide levels will continue to rise on earth due to global warming. According to David Hoffman of the Office of Atmospheric Research at the National Oceanic and Atmospheric Administration (NOAA), the average monthly mean reading of carbon dioxide was up 2.6 parts per million (ppm) in 2006, measured at Mauna Loa Observatory in Hawaii (Schmid, 2006). That increase pushed the concentration of carbon dioxide in the atmosphere to 381ppm for that year. While this increase may not at first glance seem significant, carbon dioxide levels are now 27% higher than any time during the past 650,000 years, according to a November 2005 report in Science, as reported by mongaby.com, a non-profit organization whose mission is to raise interest in issues such as the impact of trends in climate and economics. According to the same source, the "International Panel on Climate Change projects that atmospheric carbon dioxide levels could reach 450 to 550ppm by 2050." This rise in outdoor carbon dioxide is likely to affect indoor carbon dioxide levels. In July of 2013, NOAA reported the average monthly mean growth as 2.65. Since 2000, the range of average growth was 1.56 to 2.65.

In summary, carbon dioxide measurements are often used as an indicator of the quality of freshness of indoor air. Measuring carbon dioxide provides researchers with a tool for determining the adequacy of ventilation in residential dwellings.

Radon

Radon is the second leading cause of lung cancer in America according to the U.S. EPA (2005) and the MDH (2005). Radon is estimated to cause approximately

20,000 deaths each year in this country. Although lung cancer can be cured in some cases, it is the cancer most likely not to be diagnosed until treatment and cure are not possible. Among women, lung cancer now supplants breast cancer in morbidity (U.S. Environmental Protection Agency, 2007b).

Criticism regarding the validity of radon research has been quieted in the past few years. International and national research has concluded with little doubt that radon causes lung cancer. One of the most convincing of these studies was The Iowa Radon Study undertaken by a collaboration of St. Johns University, the University of Kansas, and the University of Iowa. The epidemiological study took place in Iowa, the state with the highest radon concentration in the United States. Over a thousand women took part in the 5-year study. Results suggested that cumulative radon exposure is a significant risk factor for lung cancer in women (Field et al, 2000).

Radon is found all over the United States. It comes from the natural breakdown of uranium in the soil and is released in a gas form. It enters a building from cracks and holes in the foundation. Testing is the only way to know if a particular building has a high level of radon. The U.S. EPA action level to mitigate radon is 4 picoCuries per liter as annual average (U.S. Environmental Protection Agency, 2007b).

Methods of Controlling Indoor Environments

According to the U.S. Environmental Protection Agency (2007a), source control, improved ventilation, and air cleaners are the three basic strategies to improve indoor air quality. Although Warsco and Lindsey (2003) list four strategies for the reduction of indoor air pollution: 1) source control; 2) separation; 3) filtration; and 4) ventilation, they group separation and filtration together in their research. The American

College of Occupational and Environmental Medicine (2002) suggested that mold, bacteria, dust mites, and bacterial endotoxins, all contributors to respiratory illness, can be minimized by the control of indoor relative humidity and eliminating water intrusion from the outdoors.

Based on research presented above, the control of moisture, including relative humidity, is critical for the health of occupants. This section focuses on control of indoor air quality using source control, ventilation, filtration, and to a limited degree, air cleaners.

Source Control

The control of sources depends on the pollutant. If the pollutant is VOCs from paint, for instance, the solution is to use paint with no or low-VOCs. Another option to avoid VOC exposure is simply not to bring products known or suspected to have VOCs into the living environment. Examples are furniture made from engineered wood products with high-VOC adhesives and air fresheners with specific chemicals (Anderson, 1997). Consumers may be able to request and review Material Safety Data Sheets (MSDS) to discover potentially noxious or dangerous chemicals in certain products. However, MSDS sheets are sometimes difficult to obtain and even more difficult for lay people to decipher. Consumers may test the response of family members by exposing them to the potential product to be used inside the house. However, even small amounts of a pollutant can elicit an immediate negative response in sensitive people, so care must be taken if this method is used.

Source control of moisture depends on the state of moisture: liquid, gas or solid. To reduce liquid water entry into a dwelling, good building practices should be followed. Windows and doors should be installed with flashings that prevent water entry. Exterior walls should have a weather barrier paper applied over the exterior sheathing. Adequate overhangs will help keep rain off of the dwelling and reduce the risk of water entry. Good moisture-prevention strategies were given by Iowa State University wood specialist Dean Prestemon as early as 1984. Some of his requirements included:

- Install a vapor barrier under concrete slabs
- Waterproof outside walls of foundations
- Provide proper drainage at perimeter of foundations
- Provide and air space and impervious membrane where any wood beams meet the foundation
- Provide a ground cover, air barrier and insulation for crawl spaces
- Maintain eight inches of clearance between the ground and the bottom of exterior siding
- Install flashing where different siding types or materials meet
- Install a continuous vapor barrier between the house and the attic
- Install a vapor barrier on the warm side of the exterior wall
- Use properly installed, high-quality windows and doors
- Provide a minimum of 24” overhangs on buildings
- Use flashing at valleys and dormers

Although much research has been conducted since Prestemon first presented his list, the basic information is still valid. Many of these requirements are emphasized in Lstiburek and Carmody’s book The Moisture Control Handbook (1993). This book describes and illustrates the proper building practices for moisture control based on heating and cooling needs by climate. The general strategies for moisture control in a heating climate, such as that in Minnesota, include:

- Rain control using rain screens, building papers and flashings
- Directing water away from foundations using gutters, downspouts, and correct site grading
- Control groundwater with a subgrade drainage system

- Control moisture movement by controlling air leakage by limiting leakage openings and installing air retarder systems in all of a buildings assemblies such as walls and ceilings
- Place vapor retarders in walls, roofs, and foundations to control moisture movement
- Permit wall assemblies to dry before they are enclosed
- Ventilate roof assemblies to remove moisture in all but heavily insulated roof assemblies
- Direct interior of moisture sources to the exterior by installing venting in baths, kitchen and other moisture producing rooms
- Vent clothes dryers to the exterior
- Design heating and cooling systems to control air pressure
- Ventilate enclosed spaces in a controlled manner
- Install ductwork for heating and cooling systems in conditioned spaces only
- Seal all ductwork
- Do not use unvented combustion appliances
- Control air pressures so that venting of combustion equipment is not compromised

Since 1993, Lstiburek has modified some recommendations on the building assembly, but moisture control basic strategies remain very much the same.

Radon

The U.S. Environmental Protection Agency is a leading authority on the control of radon. They have issued guidelines for radon control in new construction and for mitigation in existing buildings. In both cases, mitigation involves placing a PVC pipe from below the basement floor through the roof of the house. In some cases a fan is placed in the PVC pipe in the attic of the building to draw radon from below the basement floor, releasing it to the atmosphere above the house where it quickly dissipates. Other parts of the radon mitigation systems depend on conditions in a particular building. Negative pressures in a building can draw radon and other soil gases into the building from the soil so control of air pressure can be used in some cases to control entry of radon into a building. Although homeowners can easily test for radon in their homes, mitigation should be done by a trained and certified radon mitigator. The U.S. EPA, the American Lung Association, the Surgeon General of the United States, the Centers for Disease Control, and American Medical Association all suggest that tested levels above 4 picoCuries per liter (4 pCi/L) should be mitigated. A Curie is a unit of radioactivity, defined as the quantity of any radioactive nuclide in which the number of disintegrations per second is 3.700×10^{10} (The Free Dictionary, 2007). Correct radon mitigation procedures can be procured from the U.S. EPA (2005) and MDH (2005).

Ventilation

A major cause of poor indoor air quality, according to Health Canada, is a lack of fresh air. Health Canada defines a lack of fresh air as “not enough exchange of air between the outside and inside” (Health Canada, 2007). Ventilation is considered to be a primary means of providing fresh air for occupants inside buildings by avoiding the build up of pollutants inside the building (MDH, 2007). Ventilation fulfils the purpose of providing fresh air by bringing in outside air to dilute heat, moisture, gases, and particulates that have been built up inside the dwelling (Zhang, Wang, Riskowski, & Christianson, 2001). According to Sherman (2006), “Ventilation is principally used to maintain acceptable indoor air quality by controlling indoor contaminant concentrations--and, hence, doses--and minimizing occupant exposure to the contaminants” (Sherman, 2006, p. 94).

The ventilation standard recognized and adopted by most states is the ASHRAE Standard 62 series which was first introduced in 1973 and was titled *Standards for Natural and Mechanical Ventilation*. Since 1973, Standard 62 has been revised several times. According to Persily (2000), the purpose of 1989 version was to "specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects." Although both comfort and health are included in this statement, this has been interpreted to mean there are no medical research studies to indicate a particular ventilation rate. The standard was based on occupant response to what they considered “acceptable.”

The changes made and recently adopted in the ASHRAE 62 series (ASHRAE 62.2, 2003) have been crafted to address the “level of acceptability” for indoor air. Until recently, ASHRAE has made the assumption that air leakage and operable windows provided enough fresh air for human occupants. To that end, several changes were proposed and adopted, including local exhaust for pollutant-laden rooms such as kitchen and baths, clothes dryers vented directly to the exterior, and restrictions on the source of fresh air. However, the actual cubic feet per minute of outdoor to indoor exchange has been reduced.

In a study designed to compare several ventilation strategies, Holton and Beggs (2000) reported that natural ventilation alone is not enough to meet the 0.35 air changes per hour in typical new construction and that intentional ventilation must be provided to meet that standard.

While standards such as those developed by ASHRAE provide guidance on the amount of ventilation necessary to provide fresh air, there is some question as to whether ventilation should be continuous or if intermittent ventilation can provide acceptable indoor air quality (Sherman, 2006). When ventilation systems are being designed for new residential construction or when existing residential dwellings are retrofitted, Sherman suggests that designers and engineers should consider the concentration of indoor contaminants. However, he points out this is difficult to do because of the variance of contaminants on sometimes an hourly basis. Most designers continue to use ventilation standards as a guide.

Three European studies show contrasting results with regard to the effectiveness of ventilation on the health of occupants. In a study conducted in Oslo, Norway, Oie et al. (1999) compared 172 children with chronic bronchial obstruction with a matched control group of 172 children. There was no correlation between ventilation rates and the risk of developing chronic bronchial obstruction. There was, however, an association with exposure of children to environmental tobacco smoke, dampness, textile wall coverings, and plasticizer materials.

In a study with 181children and a control group of 359 children in Stockholm, Sweden, Emenius et al. (2003) also did not find a statistical significance between wheezing and either ventilation type or air change rate. The authors did find a systematically stronger risk between bronchial obstruction and exposure in low air change group than in the high air change group. In addition, they also found a relationship between wheezing and absolute indoor air humidity, the presence of a crawl space with a concrete slab, and window panes consistently showing condensation. The authors suggest that it might be that building quality can prevent infant wheezing.

The third study (Bornehag, Sundell, Hagerhed-Engman, & Sigsgaard, 2005), completed in a rural area of Sweden, did show that 198 children living in homes with lower ventilation rates than 202 children living in homes with a higher ventilation rate had more asthma and allergic symptoms including wheezing, rhinitis, and eczema. Interestingly, the first two studies were done in urban multi-family housing units; the Bornehag study was done in single family homes. Bornehag et al. also suggested that the higher ventilation rate in the Oie and Emenius studies "might explain why they could not find an association between ventilation rate and health" (Bornehag et al., 2005, p 279).

Occupant behavior has a profound effect on the ventilation rate in a residential dwelling. If occupants do not open windows, operate ventilation systems, or use air conditioners, indoor air quality can be compromised. A study of occupant behavior conducted in the southern part of Japan (Iwashita & Hiroshi, 1997) concluded that 87% of the total air change rate was caused by behavior of the occupants. It is imperative that occupants understand both how to control pollutants inside their homes and how to use ventilation equipment.

Persily (2006) agreed with other researchers that one of the most important determinants of indoor air quality is the amount of outdoor ventilation provided to a building. Persily questioned the building science community, challenging the standards and guidelines that have been developed. He suggested that ventilation rate measurements often show a discrepancy between design intent and performance. One way to determine performance is to measure levels of humidity, carbon dioxide, temperature, and VOC levels in buildings rather than ventilation rates.

Filtration

Filtration, traditionally intended to protect heating and cooling coils in heating and cooling mechanical equipment (Schloss, 2007), is now expected to do much more.

Filtration is now used to reduce VOCs (Chen, Zhang, & Zhang, 2005), particulates (Kulmala, Asmi, & Pirjola, 1998; Sultan, 2006) and other pollutants.

An article by Matela (2006) stated that the average human inhales approximately 16,000 quarts of air each day. That air contains around 70,000 particles; some are visible, but many are not. That same article noted that the U.S. EPA suggests that indoor air is two to five times more polluted than outdoor air. Most of the particles that humans inhale are minute in size. Matela suggested that filtration is the primary defense to protect humans from inhalation of particles. Filters considered most effective are those that remove higher quantities of smaller particles from breathable air.

Household Maintenance

In addition to using solutions that research suggests will control indoor environments to keep occupants healthy as presented in the previous sections, the Healthy Homes Partnership (2002), recommends several action steps to control pollution in living spaces. They include the following:

- Do not smoke in the house.
- Take care of spills as soon as they happen to avoid pest infestation and moisture problems.
- Open windows when using chemicals in the home to avoid inhalation.
- Air out new carpet before it is installed to avoid high VOCs.
- Do the same with new furniture.
- Keep pets out of sleeping areas.
- If the living space is likely to have lead paint, follow EPA guidelines to protect occupants from lead poisoning.
- Have any fossil fuel appliances checked for proper operation to avoid carbon monoxide poisoning.
- Follow directions for use of pesticides carefully. Or, use integrated pest management in place of pesticides.
- Use hazardous waste materials carefully and according to the manufacturer's directions. Store them where children cannot reach them.

Theory

This research is primary based on the idea that education can affect how participants act with regard to the condition of the air quality in their apartments. If they know and understand how their behavior impacts the indoor air quality in their homes and how that affects the health of their families, they would be more likely to make choices that will have a positive affect on the air inside their homes. There is an assumption in this research that adults in the family will make those decisions. To best affect the adult behavior, it is necessary to understand how adults learn. With that knowledge, the researcher can best have influence on changes that will result in a better indoor air quality.

In the educational research world, there are differences of opinion about what a theory is. Some researchers believe activities of research would be aimless without a set of assumptions as a starting point and to serve as a check on observations. (Kidd, 1959, as cited in Knowles, 1998) Others see theory as a way of summarizing facts. (Hilgard and Bower, as cited in Knowles, 1998)

In his book, The Adult Learner, Malcolm Knowles (Knowles, Holton, & Swanson, 1998) states his belief that there is a difference between education and learning. According to Knowles, education is initiated by an agent (the educator) and is designed to affect change in knowledge or skills. Learning, Knowles goes on to say is, in contrast, the “act or process by which behavioral change, knowledge, skills, and attitudes are acquired.” Learning, he says, emphasizes the person in whom the change occurs.

There are many theories of adult learning. The theory used in this research is known as Andragogy. Andragogy is best known today through the work of Malcolm Knowles, but was first used in research by German researcher Alexander Kapp in 1833. Literally, the term Andragogy is derived from "agogos" (leading) and "anere" (adult). The term is considered to be in juxtaposition to the theory of Pedagogy, meaning the art and science of teaching children. Introduced in America in the mid-1920s by E.C. Lindeman, some "use the term to suggest a theory that guides the scope of both research and practice on how adults learn, how they need to be taught, and elements to be considered when adults learn in various situations and contexts" (Henschke & Cooper, 2002).

Knowles identified several basic premises or what he refers to as "learning characteristics" to define and differentiate Andragogy (Knowles et al., 1998). They are 1) the need to know; 2) the learners' self-concept; 3) the role of the learners' experience; 4) readiness to learn; 5) orientation to learning; and 6) motivation. Each of these premises are briefly discussed here.

The Need to Know

Tough, as cited in Knowles et al. (1998), discovered that adults will invest considerable energy in determining benefits they might gain from learning something new. Thus, the role of the facilitator is to help the learner become aware of the "need to know."

Learner's Self-concept

Dependency is the typical learning concept of a child. They rely on a teacher for direction. As children age, they should become increasingly conscious of making decisions on their own and being capable of self-direction. Adults may remember this model and come into training and educational settings expecting this model to prevail. In Andragogy, adults are led to self-direction in learning just as they are in other activities. The relationship between teacher and student becomes one of reciprocity. If the theory is properly executed, the adult learner will develop a strong desire to continue the learning process.

The Role of the Learner's Experience

Children are relatively new to experience, particularly experiences that are repeated and become predictable. As people become adults and mature they accumulate a wide range and number of experiences. Andragogy uses the experiences of adults by sharing and assuring the adult learner of the importance of their experiences. It becomes a valued resource. The learning experience becomes a two-way communication in Andragogy, using techniques such as group discussion, simulation, role-playing, buzz groups, team designing, and skill-practicing.

Readiness to Learn

Unlike Pedagogy, where the main goal is to "sequence and interrelate subjects and skill-building activities to meet the requirements of competency for graduation," adult learning is mainly related to social roles of immediate concern. In the case of this research, learning is directly associated with the adults' desire to keep family members safe and healthy.

Orientation to Learning

Children tend to be subject-oriented in learning. Adults, however, are what Knowles identifies as "life-centered." He explains further that adults are motivated to learn if they perceive that learning will help them solve problems they may encounter in their lives. Knowles gives this example:

> "For years, educators in the US attempted to reduce adult illiteracy. They did so using word lists and writing lessons that had no context to the learner. When educators use words and situations that learners experience in real life situations, many of the barriers to learning are greatly reduced and even disappeared in many cases."

Motivation

While children are often learning in preparation for the future, adult learning is centered on problems rather than on a particular subject, such as mathematics or science. Andragogy is the theory of learning for problem solving in the present. The goal of learning is to improve a situation or perhaps correct something. Or, it may be learning to respond to a new reality. Motivation for change in adults is usually internal. It may be for self-esteem, increased job satisfaction, or a positive change in quality of life.

Andragogy does not suggest that structure is not used in the adult learning situation. Educators must learn to play a more facilitative role. They are resources to help supply and suggest techniques. They may suggest areas of interest that appear to be important to learners. According to Ingalls, "the role of the teacher of adults is to openly share knowledge and experience insofar as it relates to the concerns and needs expressed by the learners" (Ingalls, 1976, p 146).

Education on Indoor Air Quality

In a pilot study funded by the U.S. Department of Energy, an expanded client education program was provided to fifteen homes receiving Weatherization Assistance

Program energy measures in their homes (State of Minnesota Department of Commerce, 2012). When compared to a control group of fifteen homes, the households receiving the expanded client education, including quarterly phone calls, showed improvement in the following areas based on a t-test analysis:

- Use of a set-back thermostat for heating and cooling
- Frequency in use of bath and kitchen fans
- Frequency in changing furnace filters
- Frequency in cleaning refrigerator coils
- Cleaning light bulbs
- Turning off lights when not in use
- Turning down thermostat at night, during winter, and during daytime
- Replacing incandescent light bulbs with CFLs

This study suggested that expanded education with reinforcement can have an effect on indoor air quality through the increased use of kitchen and bath fans, frequency of changing furnace filters, and cleaning of refrigerator coils.

The next chapter addresses the methodology that will be used to test the research hypotheses.

Chapter Three. Methods

This chapter describes the methodology employed for this study, including building selection, sample selection, questionnaire description, data collection methods, testing procedures, and statistical analyses.

There were three components to this research project. They were: (1) a short questionnaire that participants were asked to complete at two separate times; (2) a three-hour indoor air quality intervention training session for those in the intervention group; and, (3) indoor air testing for temperature, relative humidity and, for a subset of the dwellings, carbon dioxide and volatile organic compounds.

Building Selection

Building selection for this study began in 2007. Relatively new buildings with similar heating and cooling systems were chosen to reduce the variability among buildings. Additionally, buildings with both immigrant and non-immigrant occupants were sought; those with a greater than 50% Somali occupancy were preferred. The area of Minneapolis chosen was because there was a concentration of immigrant families in that area of the city who tended to rent rather than own homes.

Three buildings were chosen and were located within two miles of each other. The buildings, described in more detail below, had a total of 140 units. While not completely occupied by immigrant families, the three buildings were occupied by more than 50% Somali families, one with a 90% Somali occupancy. Two of three buildings were owned by the same non-profit corporation; the third building was owned privately. All three buildings were managed by the same building management company.

Permission to conduct the research in these buildings was granted by the property owners in accordance with requirements of the Institutional Review Board (IRB) of the University of Minnesota. Owners and managers of the buildings were supportive of this research and granted permission for access to renters. The management company provided a letter of introduction and support for the researcher to present to residents as the residents were recruited (Appendix D).

Building One, a four-story building built in 2000, had a total of 80 units. Forty units were efficiency units, 24 were one-bedroom units; and 16 were two-bedroom units. Sixty-four units were considered affordable housing and had household income restrictions; the remaining 16 units were rented at market rate. All units were equipped with individual heating and air conditioning equipment. All of the floors in the units of this building, as well as in the other two buildings, were vinyl composite tile. Bathrooms fans were designed to run continuously; kitchen fans were recirculating and controlled by the residents. Domestic hot water was provided centrally to the entire building and laundry facilities were available onsite. Appliances, including ranges and dishwashers, were electric and renters paid their own electric, telephone, and cable bills. The developer and owner of Building One was interested in learning about how the building worked and how the building indoor air could be improved and maintained.

Building Two was a 48 unit, four-story building completed in 2008. Unit sizes ranged from studio to four-bedroom units; the four-bedroom units were two stories. Like Building One, each unit was equipped with its own heating and air conditioning equipment with domestic hot water provided centrally for the entire building. Shared laundry facilities were provided onsite. Bathroom fans were designed to run continuously; kitchen fans were re-circulating and were controlled by the residents. Cooking appliances and dishwashers were electric. Renters paid their own electric, telephone, and cable bills.

Building Three was a 12- unit townhouse structure that opened in February of 2005. These units were available exclusively for families whose head of household had a documented disability. Unlike Buildings One and Two, smoking was allowed inside the units in Building Three, but not in any common areas.

All three buildings were designed and built with the intent to be energy efficient and healthy for occupants. Cleaning products used for common areas were considered by management to be “green.” The two larger buildings were equipped with programmable set-back thermostats that renters were encouraged to use.

Participant Selection

The IRB directed that only 90 families could be contacted for this research with a final expected participant number of 30 households. The IRB considered this population to be vulnerable resulting in the restriction of the number of families allowed to be approached by the IRB.

Recruitment of participants took place from April of 2008 to June of 2010. The extended length of the recruitment period is explained in the next section, Recruitment Process. Of the 90 households allowed to be contacted by the IRB, 43 expressed interest in participating in the research. By the time the selection process had been completed, 13 of the original 43 who had agreed to participate had moved or were non-responsive to requests to continue with the next step of the research. When the training phase began, 30 families were still willing to participate. However, because of the nature of the paired sample research design, with half assigned to the control group and half to the intervention group, the researcher was not able to engage all willing families in the research project. An additional two families moved before final data collection could be completed, leaving 24 households who completed the study. The subject and control groups were chosen by random selection.

Recruitment Process

At the beginning of the recruitment process in 2007, only Buildings One and Three existed. Building Two was in the process of being built and was completed in 2008. Because of the extended recruitment period, Building Two was able to be included.

The recruitment plan was revised during the solicitation period. The original plan was for the property manager of the buildings to deliver to each apartment an introductory letter of invitation to participate, a consent form, and a stamped, pre-addressed envelope for the participant's response. Both the letter and the consent form were offered to all participants in English or Somalia (Appendix A1 in English; Appendix A2 in Somali). Those households willing to participate could either mail the signed consent form back to the researcher using the envelope provided or give the consent form to the property manager who would then deliver the form to the researcher.

Unfortunately, this recruiting process resulted in only three responses so plans were then revised. The property manager, a native of Somalia, began to identify possible participants through face to face contact, briefly explaining the research and inviting interested residents to meet with the researcher. Four to six people gathered at two of the buildings on four occasions. These meetings resulted in several potential participants agreeing to take part in the research. Questionnaires were available at these meetings with some participants completing the first questionnaire at the time of the meeting. The property manager and fellow participants served as interpreters.

The property manager left his position in the August of 2008 when only ten participants had been recruited up to that time. The new property manager did not speak Somali making it difficult for her to communicate effectively about the research project with the Somali residents. The researcher attempted to work with the new property manager to increase the number of participants. However, no new participants were recruited during this time. In September of 2009, a third property manager took over the management of Building One, the 80 unit building; this manager also did not speak Somali. The other two buildings were assigned a different and new non-Somali-speaking property manager.

Previously, only the property manager had been allowed to recruit participants by the property owners. Building owners were informed of the difficulty in recruiting participants and granted permission to change the solicitation process by allowing the researcher to hire a Somali-speaking recruiter who could enter all three buildings to recruit door to door. Assistance in identifying a new recruiter was provided by a staff member of one of the building owners. In June of 2009, a Somali native began recruiting participants for the study at all three buildings. The recruiter worked with the property managers to assist in identifying possible participants.

Of the 24 households who agreed to participate and did complete the entire project, ten were from Building One, 12 from Building Two, and two from Building

Three. The researcher was unable to balance the number of participants in each group from each building. In the Intervention group, seven households were from Building One, three from Building Two, and two from Building Three. In the Control group, three households were from Building One and nine from Building Two.

Incentives for households to participate in the research were approved by the IRB. Each participant received a $20 gift card after the first questionnaire was completed and received by the researcher. Participants received an additional $80 gift card after the second questionnaire was completed and the indoor air quality testing equipment had been retrieved. Those who participated in the intervention training were also provided $10 in cash to cover transportation costs.

Procedure

The questionnaire, consisting of 36 questions divided into four sections, was offered to participants in both English and Somali (Appendices B1 and B2). The first section, Your Home, contained questions about conditions in the home such as the presence of mold or moisture. Questions in the second section, Home Maintenance, focused on household practices of cleaning, cooking, and equipment use. The third section three, Indoor Air, contained questions about family perceptions of the indoor air in the home. The fourth section, Family, requested that respondents provide basic information about household members.

A head of household for each family was given the questionnaire to answer at the time of recruitment. Half of the households were assigned to the intervention group and were required to attend a three-hour intervention training program on indoor air quality (Appendix F). The member of the household who completed the first questionnaire also completed the same questionnaire at the end of the study period. This questionnaire was completed when the indoor air quality equipment was removed from the homes.

Indoor Air Quality Training

Half of the participants, the Intervention group, attended an educational training about how to manage the indoor air quality in their apartment. The content of the training was based on two publications: *Help Yourself to a Healthy Home*, published jointly by U.S. HUD, the U.S. Environmental Protection Agency, and the University of Wisconsin Extension Service, and the *RentWise* program, originally adapted from a University of Wisconsin Extension Service program by Dr. Marilyn Bruin, University of Minnesota. The *RentWise* training, designed for renters, has eight modules. The *Taking Care of Your Home* module, focusing on information and training on maintaining good indoor air quality, was revised for purposes of this study. The training for this research focused on indoor pollutants and was limited to those issues that affect health and those over which occupants had control. These included dustmites, cockroaches, mold, rodents, dust, furry pets, volatile organic compounds, cleaning products, carbon monoxide, and ozone.

The researcher presented the intervention training sessions on three different occasions, one each on December 19, 2009, February 6, 2010, and February 13, 2010, at two locations to accommodate residents and reduce the need for transportation to the sessions. Each session was held for between three and four hours. A childcare worker was provided on-site to facilitate attendance. The recruiter assisted during the training by interpreting in Somali. Attendance at the sessions ranged from three to seven heads of households.

A PowerPoint® presentation (Appendix F in outline form) was used by the researcher to facilitate the training. During the presentation, participants were asked to separate into small groups to confer and answer questions on the following topics: cockroaches, dustmites, and mold (see Appendices G1, G2, and G3). The small groups reported out to the whole group for reinforcement of the training. Participants were provided State of Minnesota Department of Health Fact Sheets on *Carbon Monoxide*, *Volatile Organic Compounds*, *Mold*, and *Ozone-Generating Air "Cleaning" Devices*. Because the fact sheets were available in English only, the recruiter provided interpretation during this exercise.

Indoor Air Monitoring and Scheduling

Each of the households was contacted to schedule placement of indoor air measurement equipment by the recruiter or by a building diagnostician contractor hired by the researcher to set up and retrieve the testing equipment. At the time of placing the indoor air measurement equipment, the recruiter or the contractor completed a brief visual survey of each dwelling (See Appendix H). The visual inspection included basic information such as measured verification of square footage, number of bedrooms, number of occupants, and documentation and location of the measuring tools. Also noted were conditions in the dwelling such as the presence of condensation on windows or walls, signs of mold in various locations, fan performance, and window covering type. This information was used to verify questionnaire responses. A common 61-day time period was used for the analysis of the indoor air quality measurements.

Testing Equipment

Temperature, relative humidity, and carbon dioxide were measured in all dwellings in the study using a HOBO U12-012 manufactured by The Onset Data Logger Company, Bourne, Massachusetts. The HOBO U12-012 is a four-channel data logger that allows for temperature, relative humidity, relative indoor light level measurements and accepts one external input. In this study, the external channel was used to collect carbon dioxide data (see below). The HOBO U12-012 data logger offers 12 bit resolution, high accuracy, 64k memory and direct USB connectivity for fast data readout to a computer. A four-channel USB, also from Onset, was used for logger launch, offload, and data viewing.

Carbon dioxide was measured using a Telaire Carbon Dioxide Detector manufactured by Telaire of Goleta, Georgia. The Telaire 7001 unit provides stable, highly accurate readings using dual-beam NDIR technology. The 7001 is equipped with a 0-4V output making it appropriate for long-term monitoring and recording. The Telaire equipment was connected to an external port of the HOBOs for recording purposes. The carbon dioxide detectors were calibrated within one week of the first placement and were left in place for between 83 and 104 days. They were not recalibrated at the end of the placement period.

Where possible, HOBOs and Telaires were placed approximately four feet above the floor on an interior wall away from drafts as recommended by the manufacturers. In some cases it was not possible to place equipment in that location due to a concern of placing instruments where children could reach them. In those cases, equipment was placed on an interior wall in a location that would not be disturbed but away from drafts.

Test kits for measuring volatile organic compounds using 3M 3500 Passive Diffusion Monitors were placed in the subset of nine units during the inspection. They opened and left in place for the required 72 hours and then collected. They were then placed in a freezer until all were collected and subsequently delivered to Braun Intertec Corporation, Minneapolis, Minnesota, for analysis. This test collection and delivery was repeated at the end of the monitoring period. At that time, only eight of the households from the first placement of the volatile organic compound measuring equipment remained in the study. Measurements of volatile organic compounds were analyzed by Braun Intertec, Minneapolis, Minnesota.

Volatile organic compounds are measured per compound. For this research, toluene was chosen as the compound to be measured because it is present in many building products. In this case, total hydrocarbons as Toluene were measured. The analysis of these results is limited to a discussion of the measurements in relationship to research on the use of VOCs and TVOCs for indoor air.

Variables and Statistical Analyses

The responses to the questionnaires were first analyzed descriptively. They were then analyzed to test hypotheses two and three. The responses on the first questionnaire and the air quality measurements at that time were compared between the control group and the intervention group using a t-test to determine that the groups were similar in their household composition, their knowledge, their behaviors, and their indoor environments at the onset of the research. Selected question responses and selected air measurements were then applied to test the three hypotheses.

For the air quality measurements, rather than use temperature and relative humidity as separate variables, indoor vapor pressure was calculated. Vapor pressure indicates most directly how many water molecules are in the air independent of temperature. Vapor pressure was calculated by the formula (ASHRAE Fundamentals, 2001):

$$\ln p_{ws} = C_8/T + C_9 + C_{10}T + C_{11}T^2 + C_{12}T^3 + C_{13}\ln T$$

where

C_8 = -1.044 039 7 E+04
C_9= -1.129 465 0 E+01
C_{10} = -2.702 235 5 E-02
C_{11} = 1.289 036 0 E-05
C_{12} = -2.478 068 1 E-09
C_{13} = 6.545 967 3 E+00
ln = natural logarithm
p_{ws} = saturation pressure, psia
T = absolute temperature, °R = °F + 459.67

The indoor vapor pressure was compared to the outdoor vapor pressure for each household. The indoor air monitoring results of vapor pressure, averaged at 15 minutes intervals, were collected and were then averaged into 12-hour periods. The average, mean, minimum, and maximum differences were then compared. A matched pair t-test was then conducted.

Hypothesis One

The first hypothesis of this research was to determine if an educational intervention resulted in lower measurements of indoor air pollutants. Measurements of pre-intervention and post-intervention were compared to determine if any changes were statistically significant. To make this comparison, an independent *t*-test was computed for each air quality variable between the control group and the intervention group. A significant difference at the .05 level in the air quality measurements would result in rejection of the null hypothesis that educational training did not result in improved indoor air quality.

Hypothesis Two

The second hypothesis was that the Indoor Air Quality intervention training would change occupant behaviors that affected indoor air measurements. A matched pair t-test comparing the behaviors of both groups before the intervention and after the intervention was completed. The behaviors tested included:

- Smoking by occupants
- Use of bath fan
- Use of kitchen fan
- Frequency of opening windows
- Greater than five houseplants
- Presence of uncovered fish tank
- Cooking type

A significant difference at the .05 level in the occupant behaviors would result in rejection of the null hypothesis that educational training did not result in improved occupant behaviors related to indoor air quality.

Hypothesis Three

The third null hypothesis of this research was that attending a three-hour indoor air quality training program would not change resident perceptions of learning about air quality in homes. This hypothesis was directly related to the Andragogy Theory employed in this research.

Each question in this section was designed to address one the six "learning characteristics" that Knowles identified in his research (Knowles et al., 1998). They are: 1) the need to know; 2) the learner's self concept; 3) the role of the learners' experience; 4) readiness to learn; 5) orientation to learning; and 6) motivation.

Responses to the questions relating to the Andragogy Theory of all participants before and after the training for the intervention group, and at the beginning and at the end of the research for the control group were compared using a *t*-test. The questions in the survey relating to the Andragogy Theory were:

1) The need to know
    - Occupant has adequate information about indoor healthy air
    - Learner needs to acquire information to keep air healthy
2) Learner's self concept
    - Learner has the ability to learn how to improve indoor air quality
    - Learner recognizes that improving indoor air is an ongoing process
3) Role of the learner's experience
    - Learner has the ability to gain information on healthy indoor air independently
    - Learning about good indoor air may be enhanced in a community setting
4) Readiness to learn
    - Learner has the ability to learn about healthy indoor air through books and pamphlets
    - Learner has the ability to learn about improving indoor air from life examples
5) Orientation to learning

- Learner agrees that it is good for everyone to know about good indoor air quality
- Learning about good indoor air quality will help protect family

6) Motivation to learn about indoor air quality

- Learning about indoor air interests learner
- Protection of family is the most important reason to learn about indoor air

A significant difference at the .05 level in the responses to the above questions assessing perceptions of learning would result in rejection of the null hypothesis.

The next chapter reports the results of the statistical testing of the three hypotheses and the comparisons by means and averages of the vapor pressure testing and the limited results of the carbon dioxide and VOC measurements. A discussion of the results is also presented in Chapter Four.

Chapter Four. Results and Discussion

This chapter begins with an overview of frequencies and t-test results to determine if the intervention and control groups were similar at the onset of the research, before the training intervention. A discussion is then presented of the results of air quality measurements taken, including temperature and relative humidity in all households, and carbon dioxide and TVOC results only in select dwellings. Next is a discussion of the impact of training on the intervention group. Chapter Four concludes with a discussion of the results of the research and the results of the tests of the hypotheses.

Comparisons of the Groups Pre-intervention Training

Household Characteristics

The questionnaire asked the participants to describe their families. The intervention group household size ranged from one to eight persons, $M = 4.0$; the control group ranged from one to seven persons, $M = 3.75$. The number of adult females (over the age of 18) in each household was similar in both groups and ranged from zero to five women. The majority of households in both groups, eight households each, had one or two adult women. The number of males in the households differed slightly and ranged from one to five males in each household. Six intervention group households and nine control group households reported one or two male members.

The number of children in the intervention group households ranged from one to six, $M = 2.4$; the number of children in the control group households ranged from one to five, $M = 2.2$. The number of households reporting zero to two children in the household was six for the intervention and seven for the control group. Four intervention group households and five control group households reported three to five children. One intervention group household reported six children but no households in the control group reported six or more children.

Statistical Analysis of Household Characteristics between Groups Pre-intervention Training. An independent group *t*-test was conducted to compare the household characteristics of the intervention and control groups prior to the training. Only one household characteristic showed significance. There was a significant difference in the number of adult household members in the groups; $t(11) = .039$, $p < .05$, with the control group reporting more adult members.

Characteristics of Home Environments

Households were asked nine questions about the environment in their dwellings. Two of these were related to items they brought into their homes and the remaining questions in this section were about conditions in their homes that may have been the result of moisture and air flow both inside the dwelling and from adjacent units.

The presence of an open water source, such as fish tanks or a large number of potted plants, can contribute to moisture in dwellings. Only two households, both in the control group, reported having fish tanks in their dwellings and both reported those fish tanks had covers. When asked about the number of more than five plants in the dwelling, one household each in both the intervention and the control groups reported more than five plants in their homes.

Four questions in the questionnaire related to possible sources of moisture in the home which may result in musty or moldy odors. One household in the intervention group and four households in the control group reported noticing musty or moldy odors.

Condensation on windows and leaky faucets in dwellings can also contribute to elevated moisture levels inside the dwelling units. In the pre-intervention questionnaire, one intervention household and three control group households reported noticing condensation on windows. One household in the control group but none in the intervention group reported leaky faucets in their homes. No households in either group reported mold growing in their homes.

Lingering odors and odors from adjacent units may indicate a lack of proper ventilation and good indoor air quality. Three households in the intervention group and five households in the control group reported that cooking odors lingered in their homes. Participants were given options of responses when asked if they could smell cooking odors from neighboring units. Five intervention households and three control group households reported never smelling odors from a neighbor's home while six of each group reported frequently or occasionally smelling odors from neighbors. One intervention group household and three control group households responded smelling odors from neighbors most of the time.

Statistical Analysis of Home Environments between Groups Pre-intervention Training. Based on independent group *t*-tests of the responses to the home environment questions, there was no significant difference between the intervention group and the control group at the onset of the research project prior to intervention training.

Health Issues

The questionnaire contained questions about the health of family members specifically related to illnesses that could be exacerbated by indoor air pollutants including allergies, asthma, and respiratory illness. While the number of family members in each household with reported allergies varied somewhat, five households in each of the groups reported family members with allergies. Similarly, six households in each of the intervention and the control groups reported that members of their households had asthma. Only one household in each group reported a member with a respiratory illness.

Smoking in a dwelling unit can all affect family members, but especially those with respiratory illnesses. When asked about members in the household who smoked, only one intervention group household reported having household members who smoked but five control group households reported household members who smoked. The number of people reported as smokers was the same; one for the intervention group and five for the control group. When asked if anyone smoked inside the apartment, the intervention group response was one; the control group response was three.

Statistical Analysis of Health Issues between Groups Pre-intervention Training. Based on an independent pairs *t*-test of the responses to the health issues questions, there was one significant difference between the intervention group and the control group. The significant difference was of the number of households in which members smoked, $t(21) = -1.828$, $p = .045$. There were more households with members who smoked in the control group compared to the intervention group.

Home Maintenance Behavior Practices

Maintenance behavior practices can also contribute to moisture and poor indoor air quality in dwellings. Questions about the choices of cleaning products, cooking practices, use of exhaust fans, pesticides, air conditioners, and frequency of opening windows, all which can affect air quality, were asked of participants.

All of the questions in the Home Maintenance Behavior Practices section of the questionnaire offered participants multiple responses. Practices varied somewhat between the groups at pre-intervention. Participants were first asked what methods were used to clean floors in their homes. Ten households in the intervention group reported using a vacuum on floors, but only one household in the control group reported using a vacuum. The use of other methods to clean floors was similar in both groups. This is likely due to the fact that most apartments did not have carpet or rugs as a floor covering and did not require a vacuum.

Of the types of cleaning products used to clean their homes, dish soap and water were used most often with twelve households in the intervention group and nine in the control group reporting its use. Bleach was the next most often used cleaner for both groups. Use of non-ammonia or all purpose cleaners was reported by four intervention group households and seven control group households. Few households in either group reported using ammonia-based cleaners.

The use of pesticides, which can affect occupants of all ages, was not a common practice by participant households. Ten households in the intervention group and eleven households in the control group reported never using pesticides inside their homes. Only two households in the intervention group and one household in the control group reported sometimes using pesticides inside their homes.

All three buildings in this study were equipped with bathroom fans that ran continuously at low speed in at least one bathroom, but not all participants were aware of this feature. In one control group household, a non-working fan was discovered at the time that indoor air quality measuring equipment was placed in the home. However, the family was not aware that it was not working. In the intervention group, six households did report that the fans ran continuously; another six households reported that they used the fan whenever someone was in the bathroom. In the control group, five households reported that the fan ran continuously, four households reported that they used the fan whenever someone was in the bathroom, but three households reported that there were no bathroom fans. Because the fans running at low speed can be very quiet, some households may have not realized that the fan was running. The fans were, however, equipped to be turned to a higher speed with a switch so some respondents may have not realized that they were on continuously and thus reported use of that switch only when someone was in the bathroom.

In all dwelling units in this research, no kitchen fans exhausted to the exterior of the dwelling unit. Air was filtered through the fan with all air returned to the kitchen. Only one household, from the control group, reported correctly that the kitchen did not have an exhaust fan. All others reported use of the kitchen fan to some degree. Three households in the intervention group and two in the control group reported using the kitchen fan during periods of long cooking. Four of the control group households and seven of the intervention group reported using the kitchen fan whenever cooking. However, five control group households reported rarely using the kitchen fan and two intervention group household reported frequently using the kitchen fan, even when not cooking.

Participants were asked about their cooking practices, which can add both moisture and pollutants to the indoor environment. Both intervention and control groups reported similar primary types of cooking practices. The number of households that reported the use of frying, baking, and boiling was very similar for both groups. However, the number of households reporting steaming as a type of cooking, which can add a significant amount of moisture to the dwelling, was four households in the control group and none in the intervention group.

Households were asked if humidifiers, which can add a significant amount of moisture to the indoor space, were used in their homes. While eleven households in the intervention group reported that they did not use a humidifier in their dwellings, one household reported using a humidifier continually. The control group responses were somewhat more varied. Six reported not using a humidifier; three reported occasionally using one; two reported only using a humidifier during the winter; and one reported using a humidifier year-round. No households reported use of a dehumidifier during the winter.

There was uniformity in the reported use of a dehumidifier, a strategy that can control moisture in the dwelling. While eleven households in the intervention group did not use a dehumidifier, one reported using a dehumidifier frequently during the spring, summer, and fall. Ten households in the control group reported not using a dehumidifier and two reported occasional use.

Because moisture can be somewhat controlled during summer months with the use of air conditioning, households were asked about the use of air conditioners, which were present in all units. Three households in the intervention group and none in control group reported continual use of the air conditioner. Other reported use of air conditioning was similar. Since participants were responsible for paying their own electricity bills, participants may have chosen not to use air conditioners because of the energy cost burden.

The temperature at which households set their thermostats was similar between the intervention and the control groups. Table 4.1 shows settings for air conditioning in the summer and Table 4.2 shows settings for heating in the winter.

Table 4.1. Thermostat Temperature Settings for Air Conditioning

	Intervention group (n = 12)	Control group (n = 12)
Below 65 degrees	0	1
65 – 69 degrees	2	2
70- 74 degrees	6	7
75 – 80 degrees	4	2

Table 4.2. Thermostat Temperature Settings for Heating

	Intervention group (n = 12)	Control group (n – 12)
Between 65 – 69 degrees	2	2
70 – 74 degrees	7	5
75 – 80 degrees	3	5

Households in both the intervention and control groups reported similar use of open windows for fresh air. Occasionally opening windows was reported by four households in each group. Frequently opening windows was reported by eight households in the intervention group and seven in the control group. One control group household reported leaving at least one window open all the time.

Statistical Analysis of Home Maintenance Behavior Practices between Groups Pre- intervention Training. Independent group t-tests were conducted on the home maintenance behavioral practices responses between the intervention group and the control group prior to the training intervention. Three responses were significantly different between the groups. The intervention group was more likely to report that they cleaned floors with a vacuum, used the kitchen exhaust fan, and that their primary cooking was by steaming.

The t-test result for cleaning with a vacuum was $t([22]) = 5.361$, $p < .001$. The intervention group reported a much greater use of the vacuum than the control group. For use of exhaust fan (kitchen), the t-test result was $t([22]) = 3.235$, $p = .004$ with the intervention group households using the kitchen fan more. For reporting steaming as a primary cooking choice, the t-test result was $t([22]) = -2.345$, $p = .028$ with the control group reporting more use of steaming as a primary cooking choice.

Perceptions of Indoor Air Quality

This section of the questionnaire focused on participants' perceptions of the indoor air quality in their homes. Questions for this section were developed based on the adult learning theory, Andragogy, described in Chapter Three (Knowles, Holton, & Swanson, 1998).

The first question asked participants to describe how they felt about the air inside their homes. Two-thirds of both groups reported that the air inside their dwellings was very good. A much smaller number (one intervention and four control) of households reported that it sometimes felt stuffy.

Responses to the remaining twelve questions in this section took the format of agreeing with a statement based on one of the six Andragogy premises, disagreeing with that statement, or having no opinion about that statement.

Two questions addressed Knowles' first premise, the need to know. The need to know suggests that learners will invest in learning if they believe they can gain from the new knowledge. The role of the researcher or trainer in this research was to assist the learner to become aware of the benefits from learning more about indoor air quality.

Most households (nine in the intervention group and six in the control group) agreed that they had the information necessary to keep air their homes healthy, a need to know premise. However, another need to know statement, "I need to know more about how to keep the air in my home healthy for my family," was agreed to by all twelve intervention group households and nine control group households.

Nearly all households in both groups in the pre-intervention responses agreed with the statement "I should be able to learn how to improve the air inside my home," and with the statement "Improving the air inside my home is an ongoing process." Both of these statements reflect on the Andragogy premise of self concept which acknowledges that adults take responsibility for the own decisions and lives.

The next two questions related to the premise of the role of the learners' experience which assumes that adult learners have over time accumulated experiences from which they can draw when faced with learning something new. However, experience can also reduce the learner's openness for new learning as habits of previous behavior are entrenched. Methods such as group discussions and simulation exercises can help stimulate the learner to be open to new learning. Again, a near equal number of households (eight intervention and seven control) agreed with the statement "I can learn what I need to know about indoor air quality on my own." However, the majority of households in the intervention group and in the control group (ten intervention and eight control households respectively) also agreed with the statement "I can learn about indoor air by sharing my experiences with people in my community."

Eleven households in each of the intervention and control groups agreed with this statement: I can learn best about indoor air by reading pamphlets and books. While this is somewhat related to the learners' experience, it falls within the Andragogy premise of readiness to learn. The importance of this premise is the timing of learning experiences to coincide with a need. There are ways to induce readiness through exposure to new ideas that may serve to advance the self-interest of the learner. In this study, the role of the trainer was to facilitate the exposure to participants by presenting ways to keep participant homes healthy.

All twelve of the of the intervention households agreed with the statement "I can learn best about indoor air through examples of real life situations," also a readiness to learn premise statement. Seven control households agreed with that statement, two disagreed, and three had no opinion.

When asked if they agreed with the statement "It is good for everyone to know about indoor air quality" and "I am most interested in finding out about indoor air quality to protect my family," nearly all households in both groups agreed. These two statements align with the orientation to learning premise which points out that adults are motivated to learn if they perceive what they are learning will be beneficial to them.

The sixth and last premise of Andragogy is motivation. Adults are more apt to value learning if what is learned is likely to provide such things as more pay, a promotion, or even self-esteem. In this case, protecting the health of family members can be a high motivator. The two questions for motivation were "Learning about indoor air is something that interests me," and "Learning about indoor air quality is important to me mostly to make sure that my home will be healthy for my family." Nearly all participants in both groups agreed with these statements.

Statistical Analysis of Perceptions of Indoor Air Quality between Groups Pre-intervention Training. For one statement response, the two groups showed a significant difference in their responses to the Indoor Air questions at the onset of the research. The statement was: "I can learn best about indoor air quality through examples of real life situations." The independent t-test statistic was $t[22] = 2.548$, $p = .018$. The intervention group was more likely to agree with the statement. No other statements showed significant differences between the groups on the Pre-intervention Questionnaire.

Comparisons of the Groups Post-intervention Training

After the training of the intervention group, the questionnaire was again administered to both the intervention group and the control group to identify any changes in responses due to the intervention. Results of the participants' responses to health issues, home environments, home maintenance practices, and perceptions of indoor air quality on the Post-intervention questionnaire follow.

Comparisons of Health Issues between Groups Post-intervention Training

Five households in each of the intervention and control groups self-reported that at least one member of the household had allergies. The number of household members of the intervention group with allergies was seven and the total number of family members with asthma in the control group was eight.

Three intervention households reported members with asthma, representing a total of five family members affected. Five control households reported members with asthma, representing a total of eight family members. Two control group households and two intervention group households reported members with respiratory illness.

The number of people reported as smokers in the post-questionnaire intervention group was ten people with two of those people smoking inside the apartment; for the control group it was six people with five of those smoking inside the house.

An overview of the frequencies for the post-training indicated little differences between the responses of the intervention and control post-training groups for health issues.

Statistical Analysis of Health Issues between Groups Post-intervention Training. An independent groups *t*-test was conducted on the health issue responses between the two groups after the intervention. There were no statistical differences between the groups.

Characteristics of the Home Environments between Groups Post-intervention Training

After the intervention participants were again asked to respond to the same questionnaire including questions about potential sources of moisture such as fish tanks, houseplants, leaky faucets, and indicators of excessive humidity in the home such as condensation on windows or musty or moldy odors. The frequency of responses between the first questionnaire and the second questionnaire for each group was compared. There were no differences in reports for the presence of houseplants, noticing condensation on windows, and in leaky faucets. However, the number of control group households that reported noticing musty or moldy odors in their dwellings went from two to four. The number of households reporting having a fish tank in the house remained the same both pre- and post-training: two for the post-training control group and no households for the intervention group. The number of households that reported noticing mold growing in the apartment went from zero households in each group to one household in each group. The number of households reporting lingering odors in their homes after cooking went from three to one household in the intervention group and from five to six households in the control group.

*Statistical Analyses of Home Environment Issues between Groups Post-intervention Training***.** Independent group *t*-tests were conducted to compare responses of the intervention and control group responses after the intervention. All but one set of scores showed no significance. The *t*-test for responses for lingering odors in the dwelling was $t(22) = 2.419$, $p = .024$. The control group households reported the presence of lingering odors in their home after cooking more than the intervention group post-intervention.

Comparison of Home Maintenance Behavior Practices between Groups Post-intervention Training

Questions in this section focused on how participants felt about their dwellings and how they cleaned their dwellings. Participants were first asked how they cleaned their floors. Respondents indicated a variety of methods; most frequently cleaning their floors with a broom, a vacuum, or a wet mop. Three households in each group (intervention and control) reported in the post-training questionnaire that they used a broom to clean their homes. All but one household in the intervention group reported using a wet mop for cleaning floors. Similar but reversed responses but were reported for the use of dry mop; one yes response for the intervention group and no yes responses from the control group.

When households were asked at the time of the post-intervention questionnaire if a vacuum was used to clean floors, four intervention group households and ten control group households responded they did not use a vacuum to clean floors.

Participants were asked to respond to a question about the types of cleaning products used. The cleaning products were ammonia-based cleaners, bleach and water, non-ammonia cleaners (all-purpose), and dish soap and water. Responses were identical for both groups for ammonia-based cleaners with eleven no responses and one yes response; seven no responses and five yes responses for bleach, and five no responses for dish soap and water compared to seven yes responses. There was a slight difference in responses to use of non-ammonia or all-purpose cleaners with eight yes and four no responses for the intervention group and three yes and nine no responses for the control group.

Participants were offered three options when replying to use of pesticides in their homes: often, sometimes, or never. Again, responses were very similar. The intervention group responses were one for ‘sometimes’ and eleven for ‘never.’ The control group responses were two for ‘sometimes’ and ten for ‘never.’

Proper air exchange is important for good indoor quality. Participants completing the post-training questionnaire were asked two questions about the use of fans in their kitchens and baths. Five responses were offered. For bath fans, the responses offered were: Home doesn't have a bath, fan is rarely turned on, fan is only turned on when someone showers or bathes, fan is turned on whenever someone is in the bathroom, and bath fan runs continuously. Responses from the groups can be seen in

Table 4.3. Comparison of Use of Bath Fans Post-intervention Training

Response	Intervention group	Control group
No bathroom fan	0	3
Fan is rarely turned on	0	1
Fan only on when showering or bathing	0	0
Fan is on when room is used	5	4
Fan runs continuously	6	4

Again, no kitchen fans exhausted to the exterior of the dwelling units. Air was filtered through the fan with all air returned to the kitchen. Participants were asked about the use of the kitchen fan. Three households in the intervention group reported rarely using the kitchen fan. Six households reported rarely using the kitchen fan in the control group. One respondent in the control group correctly responded that the dwelling does not have an exhaust fan. One respondent in the intervention group and six respondents in the control group reported only using the kitchen fan during periods of long cooking. Eight intervention group households and no control group households reported using the kitchen whenever someone is cooking.

The method of cooking can affect the indoor air. Participants were asked about their cooking habits. Cooking choices were frying, steaming, baking, and boiling. In this post training comparison, the following chart shows a similarity in all but baking.

Table 4.4 Comparison of Cooking Habits Post-Intervention Training

	Intervention group		Control group	
	Yes	No	Yes	No
Frying	5	7	8	4
Steaming	3	9	1	11
Baking	4	8	9	3
Boiling	7	5	5	7

Post-intervention households were asked again how often they used a humidifier. Three intervention group households and no control group households reported frequently using a humidifier during the winter months. One control group and no intervention groups reported using a humidifier frequently all year long. Two intervention households and three control group households occasionally use their humidifier. Seven intervention group households and six control group households reported not owning a humidifier.

Again on the Post-intervention questionnaire, participants were asked how often they use a dehumidifier in their homes. Eleven of the intervention group and ten of the control group households reported not using a dehumidifier. One intervention household reported occasionally using a dehumidifier; and one household reported continually using a dehumidifier.

Renters in all buildings pay for their own electricity. Participants were asked how often they use the air conditioners in their dwellings during the summer. Two of the intervention group and one of the control group households reported rarely using the air conditioning. Four of the intervention group and six of the control group households reported occasionally using the air conditioning. Three of the intervention group and four of the control group households replied frequently using the air conditioning; three of the intervention group and one of the control group households reported continually using the air conditioning during the summer.

Two questions in the Maintenance section of the questionnaire asked about thermostat temperature, one for the air conditioning and one for the heating. For the air conditioning temperature, three intervention and two control group households reported keeping the thermostat at 75 to 80 degrees F; seven intervention and six control group households kept their thermostat at 70 – 74 degrees F; two intervention group and three control group household reported their thermostat at 65 – 69 F for air conditioning. No intervention group and one control group household reported keeping the thermostat below 65 degrees during air conditioning.

On the heating side, one control group household and no intervention group households reported keeping their thermostats below 65 degrees F. Four control group and eight intervention group households reported keeping their thermostats from 70 – 74 degree F. Six control group and four intervention group household reporting keeping their thermostats from 75 to 80 degrees F during the heating season.

The last question in the Home Maintenance section was about the frequency of windows being open. One family in each of the intervention and control groups reported never opening windows. Four intervention group households and six control households reported occasionally opening windows. Six intervention group and three control households reported frequently opening windows. One intervention group and two control group households reported keeping at least one window open all of the time.

Statistical Analyses of Home Maintenance Behavior Practices between Groups Post-intervention Training. Independent t-tests were conducted to compare household characteristics between the intervention and control groups. There was a significance difference in four responses. The response for households using a vacuum to clean floors was, $t(22) = 2.76$, $p =.011$, with the intervention group continuing to use the vacuum more. The intervention group also made use of the bath fans more than the control group with, $t(22) = 2.36$, $p = .045$. For use of the kitchen exhaust fan, $t(22) = 2.36$, $p = .028$, the intervention group households were the higher users. The t-test for baking as the primary cooking type was $t(22) = 2.159$. $p = .042$ with the control group households reporting more use of baking as a primary cooking method.

Perceptions of Indoor Air Quality

In this last section of comparison between the intervention and control group household responses for the post-intervention training, participants were again asked to respond to questions regarding their perceptions about indoor air quality that were derived from Knowles' Andragogy theory of adult learning. For the first question in this section, respondents were asked to choose the statement that best agrees with how they felt about the air inside their home. Four intervention group and nine control group households agreed with the statement "The air inside my home is very good." Eight intervention group and three control group households agreed that the air inside their homes sometimes feels stuffy. No participants reported that the air inside their home was “not very good.”

For the remaining questions, participants were asked to respond by agreeing with a statement, disagreeing with the statement, or having no opinion about the statement. For the statement addressing Knowles’ first premise, the need to know, nine intervention group households and seven control group households agreed with the statement “I have the information necessary to keep the air in my home healthy.”

The number of respondents agreeing to the second “need to know” statement “I need to find out more about how to keep the air inside my home healthy for my family” was eight for the intervention group and nine for the control group.

All twelve participants for each group reported that they should be able to learn how to improve the air inside their homes, a self-concept statement. Also for a self-concept statement, “Improving the air inside my home is an ongoing learning process,” all twelve intervention group and eight of the control group households agreed.

The third Knowles premise, the role of the learner’ experience, was represented by two statements. For the first statement, “I can learn to what I need to know about indoor air quality on my own,” seven of the intervention group and five of the control group agreed. Nine intervention group households and four control group households agreed with the second role of the learner’s experience statement, “I can learn more about indoor air quality by sharing my experiences with people in my community.” Two of each the intervention group and the control group disagreed with that statement. One intervention group and six control group had no opinion.

The next statement, which applied to Knowles fourth premise, readiness to learn, was “I can learn about indoor air quality by reading pamphlets and books.” Nine of the intervention group households and eight of the control group households agreed with that statement. Nine intervention group households and ten control group households agreed they could best learn about indoor air quality through examples of real life situations, another readiness to learn premise.

All households for each group agreed that it is good for everyone to know about indoor air quality. Nearly the same percentage agreed they were most interested in finding out about indoor air quality to protect their family (twelve intervention households agreed; eleven control households agreed; one control group household disagreed). Both of these statements align with Knowles’ orientation to learning premise.

Two final statements reflected the motivation to learn premise of Andragogy. Twelve intervention group households agreed that learning about indoor air was a topic that interests them. Nine control group households also agreed but three control group households had no opinion.

Last, twelve intervention group households and eleven control group households agreed that learning about indoor air is important to them mostly to make sure that their home is healthy for their family. One control group household disagreed with that statement.

Statistical Analysis of Perception of Indoor Air Quality between Groups Post-intervention Training. An independent t-test was conducted to compare the responses of opinions of the intervention and control groups post-intervention training. All but two comparisons showed no significance difference. For the description of how intervention and control groups responded to feelings of the air inside their homes, there was a significance difference in the scores, $t(22) = 2.159$, $p = .042$, where more intervention group households reported the air inside their homes as good than the control group households. There was also a significant difference in the responses to the statement "Improving the air inside my home is an ongoing learning process, $t(22) = 2.159$, $p = .042$ with more intervention group households agreeing.

Impact of Training

This section examines changes in responses of the intervention group before and after training. Comparisons are made of household characteristics, health issues, home environment, household characteristics, and perceptions of indoor air quality.

Statistical Analysis of Household Characteristics Changes Pre- to post Intervention. There were no significant statistical differences for any responses for the intervention group from the time of the pre-intervention questionnaire to the time of the post-intervention questionnaire.

Statistical Analysis of Health Changes Pre- to Post-Intervention. There was one significance difference in the scores for the section of Health Issues. The number of households reporting members with asthma was fewer in the post-intervention questionnaire, $t(10) = -2.39$, $p = .038$.

Statistical Analysis of Home Environment Changes Pre- to Post-intervention. There were no significant statistical differences for any Home Environment responses for the intervention group from the time of the pre-intervention questionnaire to the time of the post-intervention questionnaire.

Statistical Analysis of Changes in Home Maintenance Behavior Practices Pre- to Post-intervention. There was one significant difference in the scores for the section of Home Maintenance for the intervention group from the time of the pre-intervention questionnaire to the time of the post-intervention questionnaire. The use of dish soap and water for cleaning from the pre- to post intervention questionnaires using a match pairs t-test and 2-tailed significance was $t(11) = 2.8$, $p = 0.17$ indicating that after training the intervention group was more likely to use dish soap and water for cleaning.

In addition, the use of steaming as a primary cooking type from the pre- to the post-intervention using a paired samples t-test and 2-tailed significance was $t(11) = 1.92$, $p = .082$ with the subject group households reporting more use of steaming as a primary cooking method on the post-intervention questionnaire.

Statistical Analysis of Perceptions of Indoor Air Quality Pre- to Post-intervention. There were no significant statistical differences for any Indoor Air Quality responses for the intervention group from the time of the pre-training questionnaire to the time of the post-training questionnaire.

Measures and Comparisons of Indoor Air Quality

Volatile Organic Compounds

Ten households, five each in the intervention group and the control group, were selected for collection of Volatile Organic Compounds measurements both pre- and post- intervention. Two households in the control group moved before the second VOC measurement could be taken. Results of the VOC measurements in parts per million (ppm) are shown in Tables 4.40 and 4.41 below.

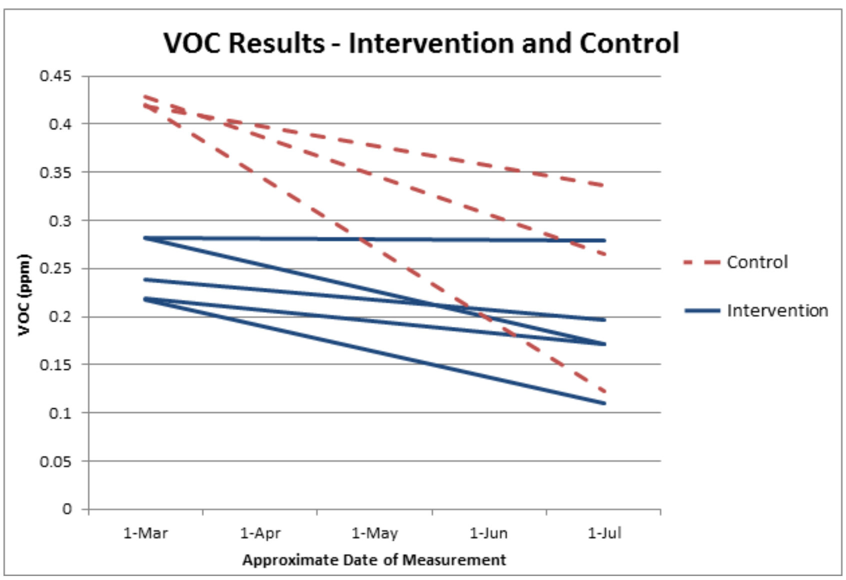
Table 4.5. VOC Results –Intervention Households

	Pre-Intervention		Post-Intervention		Difference/ Difference in % Points
	Dates	Reading	Dates	Reading	
1	3/13 – 3/16	0.219ppm	7/8 – 7/11	0.172ppm	-0.047 / 22%
2	3/13 – 3/16	0.282ppm	7/11 – 7/14	0.172ppm	-0.110 / 48%
3	3/13 – 3/16	0.239ppm	6/21 – 6/24	0.196ppm	-0.043 / 20%
4	3/13 – 3/16	0.282ppm	7/7 – 7/10	0.279ppm	-0.003 / 2%
5	3/13 – 3/16	0.218ppm	7/7 – 7/10	0.11ppm	-0.108 / 66%

Table 4.6. VOC Results –Control Households

	Pre-Intervention		Post-Intervention		Difference/ Difference in % Points
	Dates	Reading	Dates	Reading	
1	3/13 – 3/16	0.419ppm	6/21 – 6/24	0.336ppm	-0.083 / 22%
2	3/13 – 3/16	0.428ppm	6/24 – 6/27	0.265ppm	-0.163 / 48%
3	3/8 – 3/11	0.42ppm	6/24 – 6/27	0.123ppm	-0.297 / 110%

Figure 4.1. VOC Results – Comparison of Intervention and Control Groups



All readings were less at the time of the second measurement. The range in percentage differences in percentage points for the intervention group was 2% to 66%.

For the control group households, the range in percentage point difference was 22% to 110%.

Carbon Dioxide

Carbon dioxide dates of collection mimic the HOBO collection dates, March 28 to May 28 for a total of sixty-one days. The range of maximum ppm of carbon dioxide for the intervention group of dwellings where carbon dioxide was recorded was 571ppm to 2350ppm. The range of maximum ppm for the control group of carbon dioxide was 740ppm to 1270ppm. The range of averages for the intervention group was 444ppm to 764ppm; for the control group the range of averages was 551ppm to 1193ppm. The minimum range for the intervention group was 130ppm to 562ppm; for the control group it was 422ppm to 753ppm. The 130ppm reading followed a day when the carbon dioxide equipment had been turned off for two days is likely a errant reading. (See Tables 4.7 and 4.8.)

Table 4.7 Carbon Dioxide Range of Measurements for Households (ppm)

	Intervention	Control
Maximum	571 – 2350ppm	740-1270ppm
Minimum	130-562ppm	422-753ppm

Table 4.8 Carbon Dioxide Range of Averages for Households (ppm)

Intervention	Control
474-764ppm	551-1193ppm

Research presented in Chapter Two stated the American Hygiene Association suggests that levels above 800ppm will likely bring complaints from occupants of a dwelling. A similar level, 700ppm above the ambient outdoor concentration, is recommended for indoor spaces by ASHRAE. The average levels measured in almost all cases were below both of the recommendations. The highest level of 2350ppm in one intervention household was noted only for a very short period.

Relative Humidity and Temperature as Measured by Vapor Pressure

As described in Chapter Three, Relative Humidity and Temperature were converted to Vapor Pressure which allows the direct comparison of actual water droplets in the air both inside and outside on the sixty matched days of placement of the HOBOs in all dwellings. On forty-two of the sixty-one days (March 28 through May 28), the invention group average was below the control group average.

Statistical Analysis of Vapor Pressure Comparison between the Intervention and Control Averages. A matched pair t-test of the averages of the intervention group and the control group was conducted using SPSS (Norusis, n.d.). There was a significance difference in the scores, $t(123) = 13.45$, p is < (.000) with the intervention group households showing lower averages of vapor pressure than the control group.

Discussion

The first two analyses presented in Chapter Four confirmed that the intervention group and the control group were very similar with regard to household characteristics both before and after the intervention training. This outcome allows the assumption that any differences found in responses and in the indoor air testing would likely be attributed to the intervention training.

Hypothesis One.

The first hypothesis was that training and education on indoor air quality would improve the indoor air quality in multifamily apartments occupied by immigrant and non-immigrant families in Minneapolis. The null hypothesis that training and education would not improve the indoor air quality in multifamily apartments occupied by immigrant families in Minneapolis would be rejected if measurements of indoor air results from the intervention group showed a significant improvement over the results of the control group approximately two months after an adult family member from the intervention group completed a three hour training on indoor air quality. Indoor air benchmarks measured were vapor pressure as derived from relative humidity and temperature, carbon dioxide, and total volatile organic compounds.

A comparison of the measurements of the volatile organic compounds measurements showed that the VOC measurements for both groups were less at the second time of measurement. As noted in Chapter Two, there is not agreement among researchers who have conducted work on VOCs regarding how accurate results of testing are and, in fact, no complete agreement on what and how to test nor what results indicate. The VOC tested in this study was toluene, a VOC that occurs in many materials used in building products as well as cleaning products, upholstery, and particularly when those materials are new. However, after a period of off-gassing, levels of all VOCs diminish. Both buildings in this study, while relatively new, were past the age when high levels of toluene would be expected to be measured.

The intervention group percentage differences ranged from 2% to 66% less from the first measurement to the second measurement, Mean difference was .062ppm. The control group percentage changes from the first measurement to the second measurement ranged from 22% to 110% less than the first measurement, Mean difference was .181ppm. The results for both groups were far below the Health Risk Values levels of concern (400 µg/m^3 or 106.ppm) based on NIOSH (2010) recommendations for in the workplace.

Because both groups were lower at the time of the second testing than the first, the educational training and education cannot be said to have influenced a change in the level of the VOCs in the houses.

Carbon dioxide measurements were used an indicator of air exchange that can affect the quality of air in a dwelling or building. The American Industrial Hygiene Association (AIHA) suggests that levels above 800ppm will likely bring complaints from occupants of a dwelling. ASHRAE recommends a similar level, 700 ppm above the ambient outdoor concentration, for indoor spaces. The average levels of the intervention group were between 444ppm and 764ppm, which were below both of the industry recommendations. The average measurement of the control group ranged from 551ppm to 1193ppm. The low average was well below the recommendations; the high average somewhat above the recommended levels. The household with the 1193ppm average was 429ppm above the second highest average. In addition, the measured fan flow rates of the two bathroom fans in that dwelling were 32cfm and 8cfm. During the Household Review (Appendix H.), standing water was noted under the kitchen sink.

The measurements of carbon dioxide suggest that, in general, the households had adequate ventilation in their dwellings. All units in both of the buildings were equipped with fans designed to run continuously. Unless fans were not running properly or were disabled, the results were not unexpected.

The vapor pressure analysis showed a significant difference with the intervention group measuring a lower vapor pressure inside than the outdoor ambient vapor pressure in 42 of the sixty households.

Based on the results of the measurements of Vapor Pressure the null hypothesis for Hypothesis One is rejected.

Hypothesis Two

The second hypothesis was that indoor air quality training would change occupant behavior. The behavior was measured by responses on the questionnaire administered both pre- and post-intervention training. The null hypothesis, that indoor air quality training would not change occupant behavior, would be rejected if a positive statistical significance was found between responses of the group who attended the indoor air quality intervention training and the control group who did not attend.

Responses were compared with activities such as the use of bath fans and smoking in their apartments. The t-tests showed a difference in only a few of the behavioral responses in maintenance practices between the intervention and the control and groups after the intervention. Thus, the null of Hypothesis Two, that indoor air quality training does not change occupant behavior, fails to be rejected.

Hypothesis Three

The third hypothesis was based on the adult learning theory known as Andragogy. Andragogy suggests that adults need to know why they should learn something before they are willing to spend the time to learn. The hypothesis was that attending indoor air quality training would change occupants' perceptions of learning about air quality. The null hypothesis, that attending indoor air quality training would not change occupants' perceptions of learning, would be rejected if is a positive statistical difference was found between the group that attend the training and the group that does not.

To test this hypothesis, a portion of the pre- and post-intervention training questionnaire focused on the knowledge and feelings about the indoor air in the apartments of the participants. When asked about how they feel about the air inside their homes on the pre-intervention questionnaire, nine intervention households and eight control group households reported the air inside their homes was very good. However, on the post-intervention survey, eight intervention group households and only three control group households reported the air inside their homes was very good. While only four control group households reported their homes sometimes stuffy on the pre-intervention questionnaire, nine reported their homes very stuffy on the post-intervention questionnaire.

The remaining questions posed were based on Andragogy premise or assumptions. The first premise, the need to know, is based on research indicating that adults will invest in learning if they will gain from it or if not learning would have a negative affect. The first of the two questions based on this principle, "I have the information I need to keep the air inside my home healthy," indicated that the control and intervention group were closer in responses on the post-intervention than on the pre-intervention; however, the responses were not statistically significant.

On the second question of the need to know premise, “I need to find out more about how to keep the air in my home healthy for my family,” responses from both groups were very closely aligned with both groups agreeing with the statement on both the pre- and post-intervention questionnaire. In this study, the pre- and post-intervention questionnaire results for both groups may imply that protection of family is one area that is important in the population studied with or without training on indoor air quality.

Knowles’ second premise states that adults have a self-concept of being responsible for their own decisions which leads to self-direction. The two questions addressing this second premise were “I should be able to learn how to improve the air inside my home” and “Improving the air inside my home is an ongoing process” Responses to both of these statements were similar for both groups on both pre- and post-intervention questionnaire with most agreeing with the statements, indicating that these respondents have arrived at self-concept and are capable of self-direction.

In third premise, the role of the learner’s experience, Knowles recognizes that the resources for learning reside in the life experiences of the learner. The two statements relating to the learner’s experience were “I can learn what I need to know about indoor air quality on my own,” and “I can learn about indoor air quality by sharing my experiences with people in my community.” Responses from both groups on the pre- and post-intervention questionnaires were similar.

For the first statement, eight households agreed with the statement on the pre-intervention questionnaire and seven agreed on the post-intervention questionnaire. For the control group, the responses were seven agreeing on the pre-intervention and five agreeing on the post-intervention questionnaire.

For the second statement, “I can learn about indoor air quality by sharing my experiences with people in my community,” ten intervention group households agreed pre-intervention and nine agreed on the post-intervention questionnaire. For the control group, the eight households agree on the pre-intervention questionnaire; four agreed on the post-intervention questionnaire.

Adult learners become ready to learn when they are motivated to cope with real-life situations. In this study, the real life situation was to improve the air quality in their homes. Two statements in the survey addressed this premise, readiness to learn. They are “I can learn best about indoor air quality by reading pamphlets and books,” and “I can learn best about indoor air through examples of real like situations.” Responses from both groups, pre- and post-intervention questions were similar.

Eleven households in the intervention group pre-intervention and nine households post-intervention agreed with “I can learn best about indoor air quality by reading pamphlets and book on the pre-intervention questionnaire. On the pre-intervention questionnaire, eleven control group nine households agreed with the statement while eight agreed on the post-intervention questionnaire.

Twelve households in the intervention group reported agreeing with “I can learn best about indoor air through real life experiences.” Nine households agreed in the post-intervention questionnaire. For the control group, seven agreed on the pre-intervention questionnaire; ten on the post-intervention.

The fifth premise of Andragogy is orientation to living. According to Knowles, adults tend to be life centered, focusing on learning things that will help them solve problems in their lives. One statement in the questionnaire, “It is good for everyone to know about indoor air quality," focused on this premise. For this principle, every household in both groups agreed both pre- and post-intervention questionnaire.

A second statement, also relating to orientation in learning was "I am most interested in finding out about indoor air to protect my family." Results were nearly the same with twelve intervention households agreeing pre-intervention and eleven agreeing post-intervention. For the control group, ten households agreed on both the pre- and post-intervention surveys.

Adults tend to center on problems for learning and not on a particular subject such as English or social studies. The goal is to improve a situation. In this case, the statements were intended to ask if the respondents agreed that learning about indoor air quality interested them and if learning about indoor air quality was important to them to assure their home was healthy for their families. There was very little difference betweens the groups on either pre- or post-intervention questionnaires. For the statement "Learning about indoor air is something that interests me, twelve intervention households responded in agreement on both the pre- and post-intervention questionnaires. Ten control households reported agreement on the pre-intervention questionnaire and nine reported agreement on the post-intervention questionnaire.

Likewise, there is close agreement in responses to the statement "Learning about indoor air quality is important to make sure my home is healthy." The entire intervention group (12) responded in the affirmative in both the pre- and post-intervention questionnaire. Eleven households in the control group also responded in the affirmative both pre- and post-intervention questionnaires. These responses indicate that a healthy home is important to all of the families in this research.

The overall results of the tests conducted for Hypothesis Three indicate that the null fails to be rejected.

Chapter Five presents conclusions, study limitations, and suggestions for future research.

Chapter Five. Conclusions

The preceding chapters have defined the research and the three hypotheses, presented a literature review relating to the hypotheses, described the research, presented results and a discussion of the results. This chapter presents the conclusions, offers limitations of this study, and suggests topics for future research.

The results of this research failed to reject the null for Hypothesis Two and Three, but did reject the null for Hypothesis One based on one of the three indicators. That is, the training provided to the intervention group resulted in lower vapor pressure measurements than the control group. This outcome did provide the intervention group households with a lower concentration of water molecules in their dwellings that can contribute to better indoor air quality. In addition, this result cannot be attributed as a result as a result of the maintenance behavior practices of the occupants as those results showed no significant difference from pre to post-training.

The null of Hypothesis Two failed to be rejected. Although the intervention participants in this study were engaged in the training as indicated by the participation in the training activities and in the general discussion, there was not a significant difference in their responses when the pre- and post-intervention questionnaires were compared. A part of this outcome can likely be attributed to the fact that the buildings were equipped with acceptable ventilation. Although the intervention group may have become more aware of their indoor quality after the intervention, overall the building equipment was providing adequate ventilation to all for the measures documented in this study.

It is notable that the intervention group reported using both the kitchen fans and bathroom fans more frequently than the control group on the post-intervention questionnaire. Use of fans was emphasized in the intervention training sessions.

On the pre-intervention questionnaire, an equal number of households (nine) for both the intervention and control groups reported that the air inside their dwelling was very good while only four of the intervention households agreed with that statement on the post-intervention questionnaire. Perhaps the intervention group households were made more aware of the conditions inside their dwellings as a result of the intervention training.

The carbon dioxide levels in one control household, where five people were reported living, was significantly higher than the other households where carbon dioxide was measured. That household reported rarely using their fans and reported frying as their primary type of cooking. The household also reported using a wet mop to clean the floors of their dwelling. However, they did report using their air conditioner frequently during summer months, keeping the temperature between 65 and 69 degrees. This household also reported condensation on windows and lingering odors from cooking in their dwelling. As noted in Chapter Four, this household was found to have a leaky sink drain and showed standing water under the sink at the time of the House Review. The combination of these factors may be reflected in the recorded higher carbon dioxide levels.

It is interesting to note that nine control group households and seven intervention group households reported smelling cooking odors from a neighbors unit either frequently or most of the time on the pre-intervention questionnaire. On the post-intervention questionnaire, only two households reported noticing cooking either frequently or most of time and four of the control group noticed the odors either frequently or most of the time. Although the post-intervention questionnaire was administered when temperatures were milder and windows may have been open more, the responses are interesting in that they are similar.

Study Limitations and Suggestions for Future Research

Limitations and suggestions for future research are presented here in one section. Some limitations may also be the basis for suggestions for future research.

Due to limitations of funding and restrictions of the number of household contacts allowed by the Institutional Review Board, this study included only 24 households. A greater number of participants would have provided more reliability to this study.

The buildings in this study were chosen in part because they were very similar in their age and construction, thereby reducing the effect of the structure on the indoor air quality measurements. However, these relatively new buildings were designed to include features to reduce moisture and protect the health of the occupants, including continuously running bath fans and vinyl floor coverings. This may have reduced the impact of behavior of occupants on the results.

Future researchers may enhance results of studies on indoor air quality by incorporating a component of equipment maintenance. In cooperation with building owners, managers, and occupants, a survey of maintenance practices would add another dimension to the results. As results of fan measurements showed in this research, there was a fairly wide range of flow of the fans. If management would be made aware of this range, not just if the fans were working, the result could impact indoor air quality in individual units. An expansion of maintenance could also include education to occupants either on a voluntary or mandatory basis. That education could include information about cleaning products, materials brought into the house, moisture control, and other indoor air quality topics. It could also include information on how to identify medical issues that could be related to indoor air quality.

Indoor air quality measurements are most reliable when they can be left in place through four seasons in a cold climate such as Minnesota. In this study, the equipment was placed in households for only two months, narrowing the potential range of results over the seasons. If only two to three months is available for research, beginning and ending the measurements would be best during months when windows are likely to be closed. In Minnesota that is typically November through mid-March. In this study, the weather was warmer earlier than usual which may have influenced measurements and participant responses on things such as lingering odors.

Although leaving equipment in a dwelling for a full four seasons is optimal, it would likely require researchers to check on the equipment at least quarterly. With adequate funding and time for the research, using high quality measurement tools that can be monitored remotely would address several of the issues stated previously. Such equipment could be placed more effectively in a protected area in the dwellings. This would contribute to the consistency and reliability by assuring the measurement tools are less likely to be inadvertently moved or disconnected. In addition, remote access would allow researcher to know if equipment had failed or been disconnected.

A longer term study should consider the number of families moving during the study when choosing the number of participants. In this study, 13 of the original 43 who had agreed to participate had moved or were non-responsive to requests to continue when the researcher was ready to administer the questionnaire. An additional two families moved before final data collection could be completed. When the researcher picked up the final questionnaire and the measuring equipment, three more households were beginning the process of moving.

Education on indoor air quality was an important component of this research. Intervention household members were engaged and were active participants in the intervention training. However, the three to four hour length of the training was a distinct limitation of the research. A longer training, perhaps split into sessions, would allow for greater reinforcement of information on how participants can impact the indoor air quality in their homes. Although, in this research, the interpreter was able to assure that participants who did not speak English could understand the training, the time needed for interpretation reduced the actual training time.

During the three to four hour intervention training, the researcher found the intervention group to be very engaged in the learning process and willing to interact with others in the group, no matter what subject was introduced. In several instances, members of the group requested more information on not only topics covered in the intervention training, but other subjects relating to maintenance and indoor air quality. The researcher provided information to those participants by mail. Greater workgroup interaction would be possible if the intervention time were expanded.

It would also be advantageous if all training materials, including the worksheets, were translated into the language of the populations included in the study. In this study, locating and engaging translators was a difficult and lengthy process. It was discovered that there are differences in translation quality and in dialects of the Somali language, making is more difficult for participants to complete the survey without the assistance of the interpreter.

A number of suggestions could be explored for future research. For example, a different method of training and a plan for follow up with the residents after the training should be tested to determine if the outcomes would be similar. There is some evidence (State of Minnesota Department of Commerce, 2012) that reinforcement of training can influence behavior over even a short period of time. This research study was not yet completed before the research reported here was completed. A longer training time for the intervention group would enhance learning of the indoor air quality topics presented in the training. In addition, monthly or quarterly contact with participants in the intervention group would reinforce the training and allow participants to ask questions about what they learned.

Research by Corrin et al (1997) concluded that peer teacher-delivered education was successful. Future research might consider a train-the-trainer program with Somali or other immigrant population trainers delivering the training and making contact with the participants on a regular basis during the research.

The buildings in this study were chosen because they were similar, reducing the variables of construction standards and changing building practices. However, because these buildings were equipped with some features that would by their presence reduce moisture in the apartments, the variables were reduced due somewhat to occupant behavior and maintenance. Although the variables were reduced, this also likely led to fewer differences of the indoor air quality results based on occupant behavior and the impact of the training.

Working with a new immigrant population is challenging for many reasons. Potential participant families may not have a trust level with non-immigrant researchers and may have a reluctance to respond. Engaging or employing an immigrant person or a person who speaks the same language of the participant to contact and follow through with the families during the entire research period would facilitate cooperation and also reduce the time necessary to engage participants. For this research, identifying a willing translator who was able to engage the Somali families was a task that took several months. As described in Chapter Two, two different Somali translators were employed for this study due to job mobility, interrupting the research process and causing the loss of participants due to relocation.

When the non-immigrant researcher returned to dwellings to retrieve equipment, the language barrier was again challenging in the immigrant households. In many cases, grade school children served as translators. For these households, assuring that a translator is available for all household visits would reduce possible misinterpretation, including contacting the immigrant households for the purpose of scheduling visits.

In addition to the language barrier, contacting all study participants by phone, mail, or in person, was challenging. Researchers and translators undertaking this type of study must be able to be present at the study sites on a regular basis to make sure the study continues in a timely manner. In this study, the researcher learned that many of the participants, both Somali and non-Somali, did not respond to written letters and requests. The most responsive method of reaching participants was individual contact at the dwelling. The Somali interpreter and recruiter spent many evenings in the building to engage participants and make contact with the residents of the buildings.

The survey instruments in this study consisted of thirty-six questions, divided into four sections: Your Home, Home Maintenance, Indoor Air Quality, and Family. Reviewing results of this study may suggest that reducing the number of questions in both Your Home and Home Maintenance sections by eliminating those questions that showed no difference in this or other previous research provide more effective results without compromising the research. For instance, only two households in this study had fish tanks. Although fish tanks may provide moisture in a tight dwelling with no ventilation, elimination of this question would not affect the results of the research. In a similar way, the questions on cooking methods and cleaning methods were lengthy and perhaps confusing to participants.

Finally, separately researching the indoor air quality measurements and the behavior components that were combined in this research may increase the efficiency, validity, and reliability of each by reducing variables, the number of visits to the households, and the number of questions on the survey instrument.

Summary Statement

This intent of this pilot study was to discover if educational training could influence the behavior of occupants in rental property. In this case, immigrants of Somali, a growing population not accustomed to cold climates, were the target audience. Building owners of the three buildings were interested to know how their buildings were working and were supportive of the research.

To test if an educational training would be effective, an intervention training for half of participants was designed between two identical questionnaires that were administered to all participants. To enhance the research and support the findings, indoor air quality measurements were introduced to the study.

While there were many obstacles and challenges during this research, all participants were presented with an opportunity to learn about indoor air quality by virtue of being exposed to the questionnaire and for some, by having measurement equipment placed in their dwellings. The intervention group was offered a greater opportunity to learn how their actions and behaviors can influence the health and safety of their families through the training and interaction with the researcher and others who took part in the study. In close communities such as that of the Somali population, this information may well be passed on the others.

The results of this research are mixed, but can lend important information to researchers who are interested in adding more to the knowledge about how to best educate renters in particular how to change their behaviors to protect their families.

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Appendix A1. Letter of Invitation/Consent Form - English

An Invitation to Participate in Research

The University of Minnesota needs your help in conducting research on indoor air quality. Your family was selected because the owner of the building where you rent agreed to partner in this research. The purpose of this research is to measure the effectiveness of training on maintaining good indoor air quality in homes.

There are three parts to this research project. They are 1) a short survey which you will be asked to complete twice; 2) attendance at a three-part training session, and 3) non-intrusive indoor air quality testing of the air in your home. The three parts of the project are described below.

Participation in this research is voluntary. If you agree to participate, you will be randomly assigned to one of two groups. Group One will be assigned to parts one and three; Group Two will be assigned to all three parts.

Surveys. The purpose of the surveys is to discover how you feel about the indoor air quality in your home and to collect general information about your home. The survey will be sent to both groups at the beginning of the study. Both groups will be asked to complete a second survey approximately two months later. The surveys should take about twenty minutes to complete. Simply fill out the survey and return it in the enclosed, pre-paid envelope. Your responses will be confidential and anonymous to anyone except the researchers.

Training. The training program that is part of this project is known as RentWise. Those of you who are assigned to Group Two are asked to complete the nine-hour course and will receive a certificate that is recognized by many landlords as an indication that you understand the privileges and responsibilities of renting.

Indoor Air Quality Testing. Stephen R. Klossner, a professional building scientist will take measurements in the homes in the study. Some non-obtrusive testing instruments will be left in these homes until the research is complete. Tests will include some or all of the following measurements: temperature, relative humidity, carbon dioxide, and the flow rate of any exhausting fans in your home.

The scientist will also conduct a visual inspection for moisture issues. This visit will take no more than one hour. Your landlord and facility manager have agreed to allow the building to be tested and inspected. You may elect to be present during the inspection, but it is not necessary. If you elect to participate in the project, you will receive a 24 hour notice of when the testing and inspection will be conducted.

All surveys and testing results will be coded to keep them confidential. Surveys will be kept in a locked file in the offices of the co-investigator for five years; they will be destroyed after five years. If you participate in this project by completing the requirements of the group to which you are assigned, you will receive a $20 gift certificate when we receive the completed first survey. You will receive an $80 gift certificate when we receive the completed second survey.

This research is being conducted to better understand indoor air quality issues in multifamily housing in Minnesota. We are grateful for your participation in this research. A summary of the results will be shared with multifamily housing providers.

The researchers conducting this study are: Marilou Cheple and Marilyn Bruin. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact them at the University of Minnesota, 612-624-3780, mbruin@umn.edu.

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), **you are encouraged** to contact the Research Subjects' Advocate Line, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

Thank you for consideration of participation in this important research.

Sincerely,

Marilou Cheple PhD Candidate	Marilyn Bruin, PhD Associate Professor and Principal Investigator	Becky Yust, Professor

You will be given a copy of this information to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature:____Date: __________________

Signature of Investigator:___________________________Date: __________________

Appendix A2. Letter of Invitation/Consent Form - Somali

Waxaa Lagu Weydiisanayaa In aad ka Qaybqaadatid Cilmibaaris

Jaamacada Minnesota, University of Minnesota, ayaa waxay u baahan tahay inaad ka caawisid sidii ay cilmi-baaris ugu sameyn lahayd tayada hawada guryaha gudahooda. Qoyskaaga waxaa la doortay ka dib markii mulkiilaha iska leh dhismaha aad ijaarka ugu deggan tihiin uu ogolaaday inuu gacan ka geysto cilmibaaristan. Ujeeddada cilmi-baaristani waa in la cabbiro waxtarka tababar ku saabsan sida guryaha gudahooda loogu xafido hawo tayo leh oo wanaagsan.

Saddex qaybood ayuu mashruucan cilmibaarista ahi ka kooban yahay. Waxayna kala yihiin 1) xog ururin kooban oo lagaa codsanyo in aad buuxid laba jeer; 2) Ka qaabqaadashada casharro tababar ah oo ka kooban saddex-qaybood; iyo 3) tijaabo laga qaadayo hawada gudaha gurigiina iyadoon laguu gacan dhaafin; Saddexda qaybood ee mashruucan hoos ayaa lagu faahfaahiyey.

Ka qaybqaadashada cilmi baaristani waa ikhtiyaar. Haddii aad ogolaatid inaad ka qaybqaadatid, waxaa si bakhtiyo nasiib ah laguugu darayaa labo kooxood midkood. Kooxda Koowaad waxaa loo dirayaa qaybta koowaad ee cilmi baarista oo kaliya; Kooxda Labaadna waxaa loo dirayaa sadexda qaybood ee ay cilmi baaristu ka kooban tahey.

<u>Xog Ururin.</u> Ujeeddada xog ururintani waa in la ogaado fikrada aad ka haysatid tayada hawada ee gurigaaga gudihiisa iyo in la ururiyo war guud oo ku saabsan gurigaaga. Xog ururinta waxaa loo dirayaa labada kooxoodba daraasaadka bilowgiisa. Labada kooxoodba waxaa la weydiin doonaa inay buuxiyaan warqado xog ururin kale ugu dhowaan laba bilood ka dib marka ay qaataan tababarka kadib. Buuxinta xog ururintani waxay qaadanaysaa ilaa labaatan daqiiqadood. Si fudud uun xog ururinta u buuxi dabadeedna kusoo celi boqshada ku lifaaqan ee aan kaa rabin inaad lacag ku bixisid farankabooladuna ku dheggan tahay. Jawaabaha aad bixisid waa la qarinayaa oo cid aan aheyn dadka cilmi- baarista sameyanaya ma ogaan doonaan.

<u>Tababarka</u>. Barnaamijka tababarka oo qayb ka ah mashruucan waxaa loo yaqaan RentWise. Kuwiina lagu daro Qaybta Labaad waxaa laga codsan doonaa inay dhameystaan casharadan socon doona sagaalka saac waxaana la siin doonaa shahaado ay kuwo badan oo mulkiilayaasha guryaha laga ijaarto ahi u aqoonsan yihiin inay tahay caddeyn ah inaad fahansan tahay mudnaanta iyo mas’uuliyadaha ijaarka.

<u>Tijaabada Tayada Hawada Guryaha Gudahooda</u>. Stephen R. Klossner, oo ku takhususay cilmiga sayniska ee dhismayaasha ayaa cabbiraad ka qaadi doona dhowr guri oo ka mid ah kuwa cilmibaarista lagu sameynayo. Qalab tijaabo aan waxba idinka carqaladayneyn ayaa lagu dhaafayaa guryaha ilaa inta cilmibaarista laga dhameynayo. Tijaabooyinka waxaa ku jira kuwan soo socda qaar ka mid ah ama dhamaantood: heerkulka, is

barbardhiga heerarka huurka, carbon monoxide, carbon dioxide, iyo heerka socodka marawaxadaha qiiqa saara ee gurigiina ku xiran.

Saynisyahanku wuxuu kale oo baaritaan indha-indheyn ah ku sameynayaa arrimaha la xiriira qoyaanka. Baaritaankani ma qaadan doono in ka badan hal saac. Mulkiilaha guriga aad deggan tahay iyo maamulka dhismaha ayaa ogolaaday in guriga tijaabo lagu sameeyo, lana baaro. Waad joogi kartaa guriga waqtiga tijaabada lagu sameynayo, laakiin ma aha lagama maarmaan. Haddii aad dooratid inaad ka qaybqaadatid barnaamijkan, waxaa muddo 24 saacadood gudahood ah laguugu soo diri doonaa ogeysiis ku saabsan goorta baaritaanka iyo tijaabada la sameyn doono.

Dhamaan natiijooyinka xog ururinta iyo tijaabooyinka waxaa loo sameyn doonaa lambaro sir ah si loogu xafido qarsoodi. Xog ururinta waxaa muddo shan sanadood ah lagu kaydin doonaa fayl xiran oo yaala xafiiska dadka baaritaanka sameynaya; waana la burburin doonaa shan sano kadib. Haddii aad ka qaybqaadatid barnaamijkan adigoo buuxinaya shuruudaha laga rabo kooxda lagugu daray, waxaa lagu siin doonaa warqad leh qiimaha $20 oo aad dukaamada wax kaga gadan kartid (gift certificate) marka aan helno xog ururinta koowaad oo dhameystiran. Marka aan helno xog ururinta labaad oo aad buuxisayna waxaad helaysaa warqad kale oo leh qiimaha $80 oo aad dukaamada wax kaga gadan kartid (gift certificate).

Cilmi-baaristani waxay aad muhiim ugu tahay in si fiican loo fahmo arrimaha la xiriira tayada hawada guryaha gudahooda ee dhismayaasha gobolka Minnesota ku yaal oo ay deggan yihiin qoysaska badan. Mahad weyn ayaanu kuugu haynaa inaad ka qaybqaadatid cilmibaaristan. Natiijada oo kooban ayaan la wadaagi doonaa dadka guryaha ay qoysaska badani deggan yihiin laga ijaarto.

Dadka cilmi-baaristan sameyn doona waa: Marilou Cheple iyo Marilyn Bruin. Wixii su’aalo ah ee aad qabtid waad weydiin kartaa hadda. Haaddii aad gadaal su’aalo ka xasuusatidna, **waxaan kugu dhiirrigelineynaa** inaad iyaga halkaan kala xiriirtid University of Minnesota, 612-624-3780, mbruin@umn.edu.

Haddii aad wax su’aal ah oo la xiriira cilmi-baaristan haysid islamarkaana rabtid in aad la hadashid qof aan aheyn dadka cilmi-baarista sameynaya, **waxaan kugu dhiirrigelineynaa** in aad la xiriirto dadka u hadla cida cilmi-baarista lagu sameynayo, D528 Mayo, 420 Delaware St. Southeast, Minneapolis, Minnesota 55455; (612) 625-1650.

Waad ku mahadsan tahay tixgelintaada ah inaad ka qaybqaadatid cilmibaaristan muhiimka ah.

Qadarin badan,

Marilou Cheple PhD Candidate	Marilyn Bruin, PhD Associate Professor and Principal Investigator	Becky Yust, PhD Professor

Warqadan nuqul aad haysan kartid ayaa lagaa siinayaa.

Oraahda Ogolaanshaha:

Waan akhriyey warkan kor ku qoran. Su'aalo waan weydiiyey, waana la iiga jawaabey. Waxaan ogolaanayaa in aan ka qaybqaado cilmi-baaristan.

Saxiixa________________________________Taariikhda______________________

Saxiixa Baaraha_________________________Taariikhda______________________

Appendix B1. Questionnaire in English

Indoor Air Quality Assessment

Thank you for agreeing to participate in the Indoor Air Quality Assessment Study. We need your help to conduct meaningful research about the housing needs of families. Information reported to us in this survey will not be released to anyone, including your landlord and property management company.

Your Home

1. Do you have a fish tank in your home?
   ______ Yes
   ______ No

2. If you have a fish tank in your home, does it have a cover?
   ______ We do not have a fish tank
   ______ The fish tank has a cover
   ______ The fish tank does not have a cover

3. Do you have more than five houseplants in your home?
   ______ Yes
   ______ No

4. Do you notice musty or moldy odors in your home?
   ______ Yes
   ______ No

5. Do you have condensation (moisture) on the windows in your home?
   ______ Yes
   ______ No

6. Do you have mold growing anywhere in your home?
   ______ Yes
   ______ No

7. Do you have leaky faucets or plumbing in your home?
   ______ Yes
   ______ No

8. Do odors linger in your home? For instance, if you cook an evening meal, can you still smell the cooking odors the next day?
   ______ Yes
   ______ No

9. Do you smell cooking odors from your neighbors' home inside your home?

______ Never
______ Occasionally
______ Frequently
______ Most of the time

Home Maintenance

This section asks about your housing and how you clean. Remember, your opinion is important to us.

10. How do you clean the floors in your home? (Check all that apply)

______ With a broom
______ With a vacuum cleaner
______ With a wet mop
______ With a dry mop
______ Other, specify____

11. What type of cleaning products do you use? (Check all that apply.)

______ Ammonia-based cleaners (such as sudsy ammonia)
______ Bleach and water (such as chlorine and water)
______ Non-ammonia cleaners (all-purpose cleaners)
______ Dish soap and water
______ Other, specify______________________________________

12. Do you use pesticides inside your home?

_____ Often
_____ Sometimes
_____ Never

13. If your home has a bath fan installed, how often is it used?

1) ______ Our home does not have a bath fan.
2) ______ The bath fan is rarely turned on.
3) ______ The bath fan is turned on only when someone showers or bathes.
4) ______ The bath fan is turned on whenever someone is in the bathroom.
5) ______ The bath fan runs continuously.

14. If there is an exhaust fan above the range or cook top in your home, how often is it used?

1) ______ The exhaust fan is rarely used.
2) ______ The exhaust fan is used only during periods of long cooking.
3) ______ The exhaust fan is turned on whenever we cook.
4) ______ The exhaust fan is turned on frequently, even when we are not cooking.
5) ______ Our home does not have a fan above the range or cooktop.

15. Please indicate the **primary** type of cooking done in your home? Choose only one.

______ Frying
______ Steaming
______ Baking
______ Boiling
______ Other. Please indicate ________________________________

16. If you use a humidifier in your home, how often is it used?

______ We do not use a humidifier.
______ Occasionally
______ Frequently during the winter months
______ Frequently all year long
______ Continually

17. If you use a dehumidifier in your home, how often is it used?

______ We do not use a dehumidifier.
______ Occasionally
______ Frequently only during the spring, summer and fall
______ Frequently all year long
______ Continually

18. How often do you use your air conditioner during summer?

______ The air conditioner is rarely used.
______ Occasionally
______ Frequently
______ Continually

19. At what temperature do you usually keep your thermostat for the air conditioner during the summer?

______ Between 75 – 80 degrees
______ Between 70 – 74 degrees
______ Between 65 – 69 degrees
______ Below 65 degrees
______ There is no thermostat on my air conditioner.

20. At what temperature do you usually keep your thermostat for heat during the winter?

______ Between 75 – 80 degrees
______ Between 70 – 74 degrees
______ Between 65 – 69 degrees
______ Below 65 degrees

21. How often do you open one or more windows for fresh air to enter your home?
- ______ Windows are never opened
- ______ Windows are opened occasionally
- ______ Windows are opened frequently
- ______ At least one window is open all the time.

Indoor Air

22. Choose the one statement that best describes how you feel about the air inside your home?
- ______ The air inside my home is very good.
- ______ The air inside my home sometimes feels "stuffy."
- ______ The air inside is not very good.
- ______ Other

23. I have the information necessary to keep the air in my home healthy.
- ______ I agree
- ______ I disagree
- ______ No opinion

24. I need to find out more about how to keep the air in my home healthy for my family.
- ______ I agree
- ______ I disagree
- ______ No opinion

25. I should be able to learn how to improve the air inside my home.
- ______ I agree
- ______ I disagree
- ______ No opinion

26. Improving the air inside my home is an ongoing learning process.
- ______ I agree
- ______ I disagree
- ______ No opinion

27. I can learn what I need to know about indoor air quality on my own.
- ______ I agree
- ______ I disagree
- ______ No opinion

28. I can learn about indoor by sharing my experiences with people in my community.
- ______ I agree
- ______ I disagree
- ______ No opinion

29. I can learn best about indoor air quality by reading pamphlets and books.

- ______ I agree
- ______ I disagree
- ______ No opinion

30. I can learn best about indoor air through examples of real life situations.

- ______ I agree
- ______ I disagree
- ______ No opinion

31. It is good for everyone to know about indoor air.

- ______ I agree
- ______ I disagree
- ______ No opinion

32. I am most interested in finding out about indoor air to protect my family.

- ______ I agree
- ______ I disagree
- ______ No opinion

33. Learning about indoor air is something that interests me.

- ______ I agree
- ______ I disagree
- ______ No opinion

34. Learning about indoor air is important to me mostly to make sure that my home will be healthy for my family.

- ______ I agree
- ______ I disagree
- ______ No opinion

Family

This set of questions asks about you and the people who live with you. Remember, all of your answers are confidential.

35. Smoking

Do members of your household smoke cigarettes?	Yes	No
How many people smoke cigarettes? _____		
Does anyone smoke cigarettes inside your home?	Yes	No

36. Starting with yourself, please describe the members of your household. List each person's relationship to you (wife, husband, mother, father, aunt, daughter, son, etc), age, gender and the number of hours each person is home during daytime hours. Please do not list names. Circle the appropriate responses for the remaining columns.

Household member	Age	Gender (circle Male or Female)	Allergies	Asthma	Respiratory illness	Hours home during daytime
Self		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	
		Male Female	Yes No	Yes No	Yes No	

This is the end of the survey. Thank you for taking the time to complete it. Please return the survey to the University of Minnesota in the pre-stamped envelope provided.

Appendix B2. Questionnaire in Somali

Xog Ururin

Qiimeynta Tayada Hawada Guryaha Gudahooda

Waad ku mahadsantahay ogolaanshadaada ah inaad ka qaybqaadatid Daraasada Qiimeynta Tayada Hawada Guryaha Gudahooda. Waxaan u baahanahay kaalmadaada si aan cilmibaaris wax ku ool ah uga sameyno baahida guryo ahaaneed ee qoysaska. Warka naloo sheego waqtiga aan xog ururinta sameynayno cidna looma gudbin doono, xitaa mulkiilaha guriga aad deggan tahay iyo hay'adda maamusha guriga.

Gurigiina

1. Gurigiinu ma leeyahay taangiga kaluunka lagu xanaaneeyo?
   _______ Haa
   _______ Maya

2. Haddii aad leedihiin taangiga kaluunka lagu xanaaneeyo, dabool ma leeyahay?
   _______ Taangiga kaluunka lagu xanaaneeyo ma lihin
   _______ Taangiga kaluunka lagu xanaaneeyo dabool waa leeyahay
   _______ Taangiga kaluunka lagu xanaaneeyo dabool ma laha

3. Guriga ma idiin yaaliin in ka badan 5 geed oo ah talaalada guryaha?
   _______ Haa
   _______ Maya

4. Gurigiina ma ka dareentay wax urta qurunka ama bololka ah?
   _______ Haa
   _______ Maya

5. Daaqadaha gurigiina ma leeyihiin biyaha uumiga ka dhasha?
   _______ Haa
   _______ Maya

6. Ma jiraa waxyaabaha bololka ee caddaanka ama jaalada ah oo gurigiina ka baxaya?
   _______ Haa
   _______ Maya

7. Ma jiraan dareer ka imaanaya taabada qasabada biyaha ee gurigiina?
   _______ Haa
   _______ Maya

8. Urtu ma ku daahdaa gurigiina? Tusaale ahaan, haddii aad fiidkii wax karisid, maalinta dame wali ma kuu uraysaa cuntadii?
   _______ Haa
   _______ Maya

9. Cuntada laga kariyo guriga dariskiina ah urteedu ma kugusoo gaartaa gurigaaga?

______ Marnaba
______ Waqti ka waqti
______ In badan
______ Waqtiga badankiis

Daryeelka Guriga

Qaybtan waxay wax kaa weydiinaysaa guriga iyo sidaad u nadiifisid. Ogow, fikradaadu muhiim ayey noo tahay.

10. Sidee ayaad u nadiifisaa sagxada/dhulka gurigiina? (Sax mid kasta oo jirta)

______ Waxaan isticmaalnaa xaaqin
______ Waxaan isticmaalnaa vacuum cleaner
______ Waxaan isticmaalnaa tirtiraha usha leh oo qoyan
______ Waxaan isticmaalnaa tirtiraha usha leh oo qalalan
______ Wax kale. Fadlan sheeg ____

11. Waxyaalaha ama alaabta wax lagu nadiifiyo noocee isticmaashaa? (Fadlan sax dhamaan kuwa aad isticmaashid.

______ Nadiifiyiyayaasha uu curiyaha amooniyuhuku jiro (sida amooniyaha xumbada leh).
______ Biliij (Bleach) iyo biyo (sida koloriin iyo biyo)
______ Nadiifiyayaasha uusan curiyaha Amooniya ku jirin (kuwa wax kasta lagu nadiifiyo)
______ Saabuunta weelka lagu nadiifiyo iyo biyo
______ Wax kale, sheeg______________________________________

12. Gurigaaga ma ku isticmaashaa sunta cayayaanka?

_____ Badanaaba
_____ Marmar
_____ Marnaba

13. Haddii marawaxada musqusha ay gurigaaga ku rakiban tahay, si intee le’eg ayaad u isticmaashaa?

1)______ Gurigayagu ma laha marawaxada musqusha.
2)______ Marawaxada musqusha mar dhif ah baa la daaraa.
3)______ Marawaxada musqushu waxay daarantaa kaliya marka qof uu qubeysanayo.
4)______ Marawaxada musqushu wey daarantaa mar kasta oo qof musqusha ku jiro.
5)______ Marawaxada musqushu si joogto ah eyey u daaran tahay.

14. Haddii marawaxad qiiq saarta ay gurigiina kaga taalo cunta kariyaha korkiisa ama meel u dhow, in intee le'eg ayaa la isticmaalaa?

1)______ Marawaxada qiiqa saarta si dhif ah ayaa loo isticmaalaa.
2)______ Marawaxada qiiqa saarta waxaa la isticmaalaa marka cunto karin waqti dheer ah ay jirto kaliya.
3)______ Marawaxada qiiqa saarta wey daarantaa mar kasta oo aan wax karsaneyno.
4)______ Marawaxada qiiqa saarta in badan ayey daaran tahay, xitaa marka aanan wax karsaneyn.
5)_______Gurigayagu kuma laha marawaxad qiiqa saarta meesha wax lagu kariyo korkeeda iyo meel u dhow

15. Fadlan caddee noocyadan waxkaris kan ugu muhiimsan ee gurigiina laga isticmaalo?

______ Shiilid
______ Uumitayn
______ Dubid
______ Karkarin
______ Wax kale. Fadlan sheeg____

16. Haddii aad gurigiina ku isticmaashaan aalada uumiga ama dhedada ku badisa guriga (humidifier) in intee le'eg ayaa la isticmaalaa?

______ Ma isticmaalno humidifier.
______ Waqti ka waqti
______ In badan waqtiga qaboobaha
______ In badan sanadka oo dhan
______ Si joogto ah

17. Haddii aad gurigiina ku isticmaashaan aalada uumiga ama dhedada qalajisa (dehumidifier) in intee le'eg ayaa la isticmaalaa?

______ Ma isticmaalno dehumidifier.
______ Waqti ka Waqti.
______ In badan waqtiga gu'ga, xagaaga iyo dayrta
______ In badan sanadaka oo dhan.
______ Si joogto ah

18. In intee le'eg ayaad qaboojiyaha gurigiina isticmaashaan xilliga kulaylaha?

______ Qaboojiyaha si dhif ah ayaa loo isticmaalaa
______ Waqti ka waqti.
______ In badan
______ Si joogto ah

19. Heerqabowgee ayaad badanaaba saacada cabbirta qaboojiyaha ku haysaa waqtiga kulaylaha?

______ Inta u dhexaysa 75 – 80 digrii
______ Inta u dhexaysa 70 – 74 digrii
______ Inta u dhexaysa 65 – 69 digrii
______ 65 digrii ka hoose
______ Qaboojiyahayagu ma laha saacad lagu cabbiro (thermostat).

20. Heerkulkee ayaad badanaaba saacada cabbirta kuleyliyaha (thermostat) ku haysaa waqtiga qaboobaha?

______ Inta u dhexaysa 75 – 80 digrii
______ Inta u dhexaysa 70 – 74 digrii
______ Inta u dhexaysa 65 – 69 digrii
______ 65 digrii ka hoose

21. In intee le'eg ayaad hal daaqad ama in ka badan u furta si ay hawo cusubi gurigiina usoo gasho?

______ Daaqadaha waligood lama furo
______ Daaqadaha waxaa la furaa waqti ka waqti
______ Daaqadaha waxaa loo furaa in badan
______ Ugu yaraan hal daaqad ayaa mar kasta furan.

Hawada Gudaha

22. Dooro halka oraah ee sida ugu fiican u sheegaysa dareenkaaga ku aaddan hawada ku jirta gurigiina gudihiisa? Fadlan sax dhamaan kuwa khuseeya.

______ Hawada gurigayga gudihiisu aad ayey u wanaagsan tahay.
______ Hawada gurigaygaga gudihiisu marmar waxay noqotaa mid cabbur leh
______ Hawada gurigayaga gudihiisu aad uma wanaagsana.
______ Wax kale

____

23. Macluumaadka lagama maarmaanka u ah sida hawada gurigayaga gudihiisa loogu wado mid caafimaad leh waan haystaa.

______ Waan waafaqsanahay
______ Waan khilaafsanahay
______ Wax fikrad ah kama haysto

24. Waxaan u baahnahay in aan wax kasii ogaado sida hawada gurigeyga gudihiisa aan ugu wado mid caafimaad u leh qoyskayaga.

______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

25. Waan baran karaa sida loo hagaajiyo hawada gurigayaga gudihiisa.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

26. Hagaajinta hawada gurigayaga gudihiisu waa waxbarasho joogto ah.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

27. Aniga ayaa iskay u baran kara waxa aan uga baahanahay hawada tayada leh ee gurigayaga gudihiisa.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

28. Aniga ayaa wax ka baran kara hawada guriga gudihiisa marka aan la sheekaysto dadka aan is naqaan.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

29. Sida ugu wanaagsan waxaan hawada tayada leh ee guriga gudiisa uga baran karaa akhriska buugta iyo xaanshiyaha lagu qoro wararka ku saabasan.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

30. Sida ugu wanaagsan waxaan hawada guriga gudihiisa uga baran karaa xaaladaha waayo-aragnimada nolosha
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

31. Qof walba wey u wanaagsan tahay inuu wax ka ogaado hawada guriga gudihiisa
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

32. Waxa ugu weyn ee aan u daneynayo in aa ogaado hawada guriga gudihiisa waa si aan u xafido qoyskayga.
______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

33. Wax ka barashada hawada guriga gudihiisa waa wax aniga i xiiso geliya.

______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

34. Wax ka barashada hawada guriga gudihiisa waxay inta badan aniga muhiim iigu tahay si aa u hubiyo in gurigu uu noqdo mid caafimaad u leh qoyskayaga.

______Waan waafaqsanahay
______Waan khilaafsanahay
______Waxa fikrad ah kama haysto

Qoyska

Qaybta hore ee su'aaluhu waxay wax ka weydiinayaan adiga iyo dadka kula nool. Ogow, dhamaan jawaabahaagu waa qarsoodi.

35. Sigaar Cabid

Dad ka tirsan qoyskiina oo sigaarka caba ma jiraan? Haa Maya
Meeqa qof ayaa sigaarka caba? _____
Qofna ma ku cabaa sigaarka guriga dhexdiisa? Haa Maya

36. Adigoo naftaada ka bilaabaya, fadlan ka warran xubnaha ka tirsan qoyskaaga. Tax waxa uu qof waliba adiga kuu yahay (xaas, nin, hooyo, aabe, eedo, habaryar, gabadhaada, wiilkaaga iwm), da'da, jinsiga iyo inta saacadood ee qof waliba guriga joogo waqtiga maalinimada. Fadlan magyadooda ha qorin. Goobo geli jawaabaha ugu haboon ee khaanadaha soo hara.

Qofka ka tirsan qoyska	Da'da	Jinsiga (Goobo geli Lab ama Dhedig)	Xasaasiyad (alarji)	Neefta	Jirrooyinka la xiriira neefsashada	Saacadaha guriga la joogo waqtiga maalinimada
Naftaada		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	
		Lab Dhedig	Haa Maya	Haa Maya	Haa Maya	

Xog ururintii halkan ayey ku dhamaatay. Waad ku mahadsantahay waqtiga aad gelisay inaad buuxiso. Fadlan xog ururintan u soo celi University of Minnesota adigoo kusoo diraya boshqada farankaboolada leh ee lagu siieyey.

Appendix C. Request for Participant Contact Information

Indoor Air Quality Research
University of Minnesota

Dear Participant,

We need your address and phone number to be able to reach you to schedule the RentWise training and the visit to your home to place the measurement equipment. We will not use your name, address, or phone in any publications that result from this research, nor will any participant be identified in any discussions or presentations.

Name (please print) ____

Address ______________________________________Apt________________

City _____________________________State ___________Zip ___________

Phone ____

Please indicate the best time to reach you by phone: ______________________

Thank you for your willingness to participate in this research.

The researchers conducting this study are: Marilou Cheple and Marilyn Bruin. If you have questions, you are encouraged to contact Marilyn Bruin at the University of Minnesota, 612-624-3780 (mbruin@umn.edu).

Appendix D. Memo from Building One Owner to Participants

[redacted] International, Inc.
Housing Management Specialists
[redacted]
Bloomington, IN 47404
812-[redacted] Voice 812-[redacted] Fax

MEMO

July 12, 2007

TO: Residents of [redacted]

FROM: [redacted], Regional Property Manager

RE: University of Minnesota Air Quality Study

Dear Residents,

[redacted] has been selected by the University of Minnesota for an air quality study. Though we are excited about this, we are in no way involved with this study, other than to facilitate access into the building for those conducting the research. [redacted] International employees will not be looking at your surveys, or be privy to any information gathered in this study. We want to make this clear so that you feel comfortable participating in this study, and answering the questions in the survey as honestly as possible.

There is still a lot to learn about how daily routine affects the quality of air that we and our children breathe in. This is an exciting opportunity for you and your family to help everyone learn more about this. We would like to thank you in advance, for your participation and involvement in this study, should you chose to do so.

If you have any more questions about confidentiality, or any other concerns, please feel free to stop by the rental office and speak with [redacted]. You can also reach me at 612-[redacted].

Sincerely,

[redacted]
Regional Property Manager
[redacted] International

EQUAL HOUSING OPPORTUNITY

Appendix E. Completion of First Survey Letter

September 4, 2008

Dear Research Participant,

We want to thank you for agreeing to participate in the Indoor Air Quality Research Project. As you know, you have agreed to complete two surveys, attend an educational program if you are selected to do so, allow testing equipment to be placed in your home for up to three months, and complete another survey.

Because you have completed the first survey, a $20 Target gift card is included with this letter.

Recruiting participants has taken longer than we anticipated. This has delayed the educational component of the research and the testing. We want to assure you that we are continuing the research and will be contacting you to set up testing and the educational program as soon as our participant goal is met.

If you have questions or if for some reason you can no longer participate, please call Marilyn Bruin at 612-624-3780.

Again, thank you for your willingness to take part in this research.

Marilou Cheple, PhD Candidate
Marilyn Bruin, PhD
Becky Yust, PhD

Appendix F. Training Presentation (Outline format)

RentWise

Healthy House Healthy Home

- Most people spend over half of their time inside their homes.
- This presentation will teach you how to keep the indoor air inside your home healthy for your family.

Common Health Concerns

- Allergies
- Asthma
- Respiratory illness
- Lead Poisoning
- Poisoning from chemicals
- Carbon monoxide poisoning

Common Health Problems

- Tiredness
- Trouble with concentration
- Headaches
- Flu like symptoms

Medical Advice

- Check with medical professionals if anyone in your home has symptoms that last for a week or more:
  - Wheezing
  - Coughing
  - Trouble breathing
  - Eye, nose or throat irritations
  - Itching or skin rashes

Reducing Triggers in Your Home

- Dust mites
  - Dust mites are bugs that are too small to be seen without the use of a microscope.
  - They live on the dead skin that humans and pets shed.
  - Some people are allergic to their droppings (feces).
  - 100,000 dust mites can live in one square yard of carpet.

Reducing Triggers in Your Home

- Possible Symptoms from Dust Mites
  - Hay fever
  - Watering eyes
  - Runny nose
  - Itching
  - Sneezing
  - Asthma or difficulty in breathing
  - Eczema (skin roughness) in infants

Reducing Triggers in Your Home

- These conditions can lead to a high population of dust mites:
  - Poor ventilation
  - High humidity
  - High temperatures (above 70 F / 20 C)
  - Indoor air pollution such as tobacco smoke or car fumes.

Reducing Triggers in Your Home

- **Dust mites**
  - Beds are a prime habitat for dust mites. *We spend about a third of our time in our beds.*
  - A typical used mattress may have anywhere from 100,000 to 10 million mites inside.
  - Ten percent of the weight of a two year old pillow can be composed of dead mites and their droppings.
    - Buy new pillows every about every five years.

- **Dust mites – What to do about them**
  - Use zippered plastic or specially made mattress and pillow covers beneath sheets and pillowcases
  - Wash sheets, blankets, and pillowcases every week in hot water.
    - The water temperature should be above 130 degrees Fahrenheit.
  - Keep the relative humidity in your home below 50%

- **Dust mites – What to do about them**
  - Keep your house clean.
  - Use a good HEPA [***High Efficiency Particulate Air]*** vacuum.
  - If you have someone in your household with allergies, you may want to use a good air filter.

Cockroaches

- Cockroaches are fast moving insects that usually active during the night time.
- They hide in crevices and cracks during the day time or if lights are turned on at night.
- There are several types of cockroaches.
- They range in size, but are often about 1” in length.

Cockroaches

- Cockroaches consume a wide variety of foods, including
  - garbage
  - stored food

- feces
- greases
- food scraps
- hair
- paper
- dead animal or plant material

Cockroaches

- Cockroaches can transport disease organisms from dirty areas like garbage cans and sewers to clean areas like countertops, in food, and furniture.
- Cockroaches may transmit
  - Bacteria that cause food poisoning
  - Hepatitis
  - Dysentery
  - Typhoid

Cockroaches

- Disease organisms are carried
  - on the outside of the insects' bodies
  - or they pass through the digestive tract and are distributed with fecal materials.
- Cockroaches also regurgitate repeatedly when feeding
  - these secretions will contaminate stored foods.

Cockroaches

- If you have a very large population of cockroaches in your home, you may notice an objectionable odor.
  - That odor is a combination of their feces and saliva.

Controlling Cockroaches

- The most important part of cockroach control is cleanliness.
- You should also control moisture in your home to prevent cockroach infestation.

Controlling Cockroaches

- Store food in tightly sealed containers.
- Clean up spills and crumbs right away.
- Empty your garbage often.
- Repair or replace garbage containers that are broken or have cracks.
- Wash dirty dishes right after eating.

Controlling Cockroaches

- Don’t leave out pet food or water overnight.
- Fix plumbing leaks and drips.
- Seal cracks where roaches and other bugs hide or get into your home.
- Rinse containers that are to be recycled before storing them.

Controlling Cockroaches

- If you notice even a few number of cockroaches, notify your manager immediately.

- Your building manager and owner do not want cockroaches in your building and will take measures to control them.

Cockroaches
- Use insecticides wisely and safely. Because cockroaches are often associated with food preparation areas, use extreme caution to avoid contaminating utensils or food with the spray.

Cockroaches
- Cockroach "Baits" make cockroach control much easier and safer.
  - Bait can be purchased in ready-to-use plastic stations (disks) or as a granular material
  - Lightly scatter the granular bait under appliances, sinks or other areas that are inaccessible to children and pets.
  - One thorough treatment will usually protect the home for at least two to three months.

Cockroaches
- Baits and other methods to control cockroaches and other bugs work best when coupled with good cleanliness.
- General cockroach chemical treatment should be done by your property management team. That is why it is important to inform them if you see even a few cockroaches or other bugs.

Roach Control - Why Worry?
- Contaminate or damage food
- Damage wiring
- Contribute to allergies

Prevention
- Don't bring roaches with you
- Don't feed them
  - Use tightly covered food containers
  - Wash dirty dishes
  - Take garbage out daily
  - Fix leaky faucets and pipes

Roach Control - Getting Rid of Roaches
- Use roach traps to determine where roaches are living
- Apply insecticides near where roaches are living
- Apply insecticide with care to keep it away from pets, children, dishes, and food

Furry Pets
- Furry pets - dogs, cats, hamsters and gerbils
  - Protein in the saliva, skin flakes, urine, feces and hair of these animals can trigger allergic reaction and asthma attacks.

- Pet allergen levels have been found to remain in the home for several months after the pet is removed.
    - Even when the home is cleaned well.

Furry pets
- Washing pets regularly does not reduce allergens for any length of time.
- Allergens can be brought into a home on clothing even though no pets are in the home.
- Animal allergens are often detected in locations where no animals are housed.

Furry pets
- The most effective method to control animal allergens is to keep your home pet-free.
- If you have pets, keep them
    - isolated
    - out of bedrooms
    - away from upholstered furniture
    - away from stuffed animals
    - away from carpets

Furry pets
- If you have pets in the house, vacuum carpets, rugs and furniture two or more times per week.

Dust
- House dust is not dust that blows in from the outside.
- House dust is produced inside the home from several sources.

Dust
- House dust is produced from
    - the breakdown and release of plant and animal materials used in the home, such as:

pillows	clothing
cotton	blankets
jute	upholstered furniture
wool	mattresses
fabrics	animal and human hair

Dust
- Dust is made up of small particles of these and other materials.
- These small particles float around in the air.
- The smallest of these particles can be drawn into the lungs of humans when they breathe.

Dust
- When the very small particles are drawn into the lungs they can cause
    - Coughing, wheezing and shortness of breath
    - Aggravated asthma
    - Decreased lung function
    - Lifelong respiratory disease
    - Lung cancer

Dust

To keep dust to a minimum in your home:

- Clean your home often
  - Anyone with asthma or allergies should NOT be the person cleaning or
  - Should wear a mask (you can buy them at the drug store)
- Clutter makes it hard to keep a home clean so try to reduce clutter
- Store belongings in plastic or cardboard boxes

Dust

To keep dust to a minimum

- Avoid carpeting and rugs. Hard floors such as vinyl, wood or tile are much easier to keep dust-free.
- If you do have carpet or rugs, vacuum often
- Use special filter, called a HEPA (High Efficiency Particle Air) filter in your vacuum.

Dust

- Stand alone air filters may help some to remove particles from the air inside your home.
- Be sure to read the labels to make sure you purchase an air filter that is the correct size for the space you want to filter.

Carbon monoxide

- Carbon monoxide (CO) is a colorless, odorless gas.
- CO is produced when any fossil fuel such as gas or wood is not burned properly.

Carbon monoxide

- Improper burning could be due to
  - Clogged burners in the gas furnace, hot water heater or range
  - Incorrect gas pressure where the gas comes into the house or appliance
  - A clogged chimney in appliances
  - Not enough air to the appliance
  - A wood burning fireplace that isn't properly attended

Carbon monoxide

- Other CO sources
  - Starting or running a car in an attached garage
  - Using an unvented space heater inside a home

Carbon monoxide

- Health concerns include
  - Low levels can cause flu-like symptoms, headaches, dizziness, or a sleepy feeling
  - High levels can cause death

Carbon monoxide

- If you notice any of these symptoms, especially if several members of the family experience them, leave the house and call 911 from outside the home.

Carbon monoxide

- What to do to protect your family
  - Install a carbon monoxide detector outside bedrooms.
  - Have all fossil fuel appliances checked by a professional at least every other year.
  - Never use a gas range to heat a room.
  - Keep gas range burners clean.

Carbon monoxide

- What to do to protect your family
  - **N**ever use an unvented gas or propane heater in your home.

Mold

- Mold is a fungus.
  - Fungi are naturally occurring single-cell organisms that make up about 25% of the earth's biomass.
- Molds feed on organic materials such as wood and wood products, fabric, paper and much more.

Mold

- Mold and mold spores
  - are everywhere
  - grow throughout the natural and built environment
  - are present both indoors and outdoors
  - have an important function in our world
    - they break down dead materials

Mold

- Need three things to survive:
  - Moisture
  - Nutrients
  - Oxygen
- They also need a suitable place to grow

- *If not for mold, the earth would be miles high in garbage. Molds are decomposers of dead organic materials such as leaves, trees, and plants. Under some conditions, mold will also decompose non-living materials such as drywall and other materials commonly found inside buildings.*

How mold grows

- Mold produces spores
  - They are very small (some are microscopic)
  - They spread easily through the air
  - Spores land on "stuff" and will grow if and when conditions are correct

- Some molds can germinate in as little as four hours if they have a food source (non-living organic material such as drywall, wood, paper, leather, or fabrics), water, and oxygen. Molds can even grow on inorganic material such as glass or metal if dust or soil particles are present on the surfaces.

Can mold make people sick?

- We do not know all the health effects that mold spores or the mycotoxins produced by molds can cause. However, health studies show they can trigger allergic reactions and asthma attacks.
- We do know that upper respiratory illness is often reported by people exposed to wet conditions where mold is present.

Who is at risk?

- These groups of people may be affected more severely and sooner than others
  - Infants and children
  - Elderly people
  - People with respiratory conditions
  - People with asthma or allergies
  - People with weakened immune systems
    - Chemo patients
    - Organ transplant patients
    - Those with HIV

Are some molds worse?

- Some types of mold can produce chemical compounds called mycotoxins.
- Some produce toxins called aflatoxins.
  - These are usually found only in grain and in southern climates. Aflatoxins are potentially lethal.
- Most molds may cause the reactions mentioned before, but as of now there is no medical proof of disease attributed to mold.

Should you test for mold?

- Most mold experts say NO
- MDH gives this advice:
  - Investigate, don't test

- **Use your NOSE**
  - If you see or smell mold (musty odor), assume you have a mold problem

- **How do I find mold?**

  Look for it
  - Cottony, velvety, granular, leathery
  - White, gray, black, green, yellow, brown
  - Fuzzy growth or just discoloration

- **Smell it**
  - Musty or earthy odor

Where should I look?

- Areas with noticeable odor
- Where there might be excess moisture
  - Basements
  - Under sinks
- Underneath and behind materials and furniture
  - Under carpets
  - Behind furniture or boxes placed right next to outside walls

What to do if you find mold

- Clean it up!
  - Identify and fix any moisture problems
    - Flooding
    - Condensation
    - Water on basement floors
    - Plumbing leaks
    - Improper venting of combustion appliances
    - Improper venting of clothes dryer
    - Inadequate venting of kitchen and baths
    - Humidifier use

What to do if you find mold

- Dry all wet materials immediately
  - For severe problems use wet vacuums, fans, and dehumidifiers

- **Remove and dispose of contaminated materials**
  - Fabric covered furniture, sheetrock, insulation, carpet, wood products, ceiling tiles, etc. may be too contaminated to save

What to do if you find mold

- Protect yourself during clean-up
  - Wear gloves
  - Use a facemask
    - Use a minimum of medium efficiency filter (N-95)
  - Use eye goggles
  - Cover your body – long sleeves, pants

- **Make sure you protect others**
  - Keep children out the area
  - Bag waste
  - Use plastic sheeting to protect the area

What to do if you find mold

- Clean all hard surfaces
  - Soap (non-ammonia) and hot water applied with a stiff brush removes mold
    - A commercial cleaner also works
  - Rinse area with clean water

        - Dispose of safely

- Disinfect if desired
    - After cleaning and drying, you may apply bleach (1/4 – ½ cup per gallon)
    - Spray on with a spray bottle or sponge on
        - Collect any run-off and dispose of properly

Mold
- Mold is everywhere
    - Mold needs water, a food source, and oxygen to grow.
- Since a food source is almost always present and mold spores are everywhere, controlling moisture is the key to keeping mold out of your home.

What about ozone?
- Ozone is a known irritant of the lungs and respiratory system
- Studies have shown that ozone, even at high concentrations, is not effective at killing airborne or surface mold.

How to avoid ozone in your home
- Ozone generators are sold as a method of “cleaning” the air inside your home.
- This is not true.
- Ozone can harm you and your family members.
- DO NOT place an ozone generator in your home.

Volatile Organic Compounds
- Volatile Organic Compounds are
    - Chemicals that evaporate easily at room temperature
    - They include
        - Paints
        - Carpets
        - cleaning products
        - Hobbies
        - Furniture
        - Hair spray and other beauty products

Volatile Organic Compounds
- Health effects
    - Irritation
    - Headaches
    - Can exacerbate asthma
    - Eye, nose, and throat irritation
    - Loss of coordination
    - Nausea
    - Damage to liver, kidneys, and central nervous system

Volatile Organic Compounds

- What to do about VOCs
  - Carefully select materials you bring into your house
  - Carefully select products you buy
  - Seal or encapsulation some products with high VOCs
  - Use whole house ventilation

Why clean?

- To avoid illness and injuries
- To avoid problems with cockroaches, rodents, other bugs
- To make your property last longer
- To prevent fire hazards

Basic Cleaning Supplies

- Broom
- Dust pan
- Rags (Pieces of old cotton towels are great)
- Scrub brush or nylon scrubbing pad
- Dishpan or bucket

Basic Cleaning Supplies

- Dish soap
- Bleach
- Vacuum With beater bar (if you have carpeting)
- Toilet bowel brush
- Plunger

Storing cleaning supplies

- Store cleaning supplies out of the reach of small children.
  - Put bleach and cleaning supplies on a high shelf.

Kitchen Cleaning Tasks
Immediately

- Rinse dishes after use and stack in dish pan or dish washer
- Wash or soak utensils used for cooking
- Wipe up spills on floor

Daily

- Wash dishes, sink, and counters
- Sweep floor
- Clean stove top after every use to prevent baked-on dirt
- Pick up trash and empty trash can

Weekly

- Mop floors
- Disinfect counters and cutting boards using bleach water

Every Other Month
- Clean filters from range hood
- Clean oven
- Clean refrigerator and defrost if required

Bathroom Cleaning Tasks
Immediately
- Run exhaust fans after showers or baths - 20 minutes minimum
- Rinse out sink and tub after use
- Wipe up spills on floor

Weekly
- Wipe down sink and tub surroundings with all-purpose cleaner
- Clean toilet bowl
- Wipe toilet seat and outside of toilet bowl with all-purpose cleaner
- Wash floor with all-purpose cleaner
- Clean tub with low abrasion cleaner once a week

Every Other Month
- When mold appears on grout or wall surfaces, scrub with solution of 1/4 cup of chlorine bleach and one quart of water or simply use detergent in water

Carpet Care
- To protect heavy traffic areas, use door mats near outside doors

Immediately
- Pick up food and other spills immediately

Weekly
- Vacuum carpeting regularly, especially in high traffic areas

Controlling Indoor Pollutants
1. Source Control
2. Ventilation
3. Air Cleaning
4. Exposure Control

Source Control
- Don't bring items into your home that contain pollutants.
    - Don't pick up furniture from off the street.
    - Don't purchase furniture that has a strong and offensive odor.
    - Use low VOC paints and cleaning products.
        - Cleaning products do not have to have a strong odor to work properly.

Ventilation
- Run kitchen and bath fans whenever there is moisture in your home.

- Run them regularly to avoid moisture build up.

Air Cleaning

- You may want to purchase air cleaning equipment if someone in your family is especially sensitive to pollutants.

When to contact your

Property Manager

- Report the need for repairs immediately
  - If there are leaks in sinks, toilets
  - Toilet clog up
- If you have consistent condensation on windows
- If you notice even a few cockroaches, mice or other bugs or rodents
- If exhaust fans do not work properly

Discussion Activity for Cockroaches in Your Home

You have been given a cardboard box full of clothes from a friend. You suspect your friend may have cockroaches in her home. In the next week you notice two small cockroaches in the cabinet under your kitchen sink.

Think through this situation for a minute or two. Then discuss with the others at your table what you think you should do.

After you have thought about what you would do, discuss the options listed below and report which ones your group thinks are appropriate.

1. Since you only see two small cockroaches, you do nothing.

2. You call the apartment manager immediately to report the cockroaches.

3. You go to the store and purchase bug spray and spray in the cabinet.

4. You pay special attention to keeping your kitchen clean and making sure food is stored in tight containers, that dishes are cleaned right after they are used, and you wipe the counters and floors regularly.

5. You go to the store and purchase cockroach "bait" packets and place them in you kitchen.

Add any other responses that your group thinks are appropriate.

What would you do if the same situation happened again?

Report your findings to the large group.

Discussion Activity for Dustmites in Your Home

Dustmites are everywhere. Too many dustmites can affect people with allergies and other sensitivities.

For this activity, assume that someone in your family has allergies.

Review the six suggestions below for how to protect against dustmites.

1. Control the humidity in the house to be below 50% Relative Humidity.

2. Purchase special covers for pillows.

3. Wash bedding in hot water every week.

4. Use a HEPA filter on your vacuum and vacuum often.

5. Use an air filter in the bedroom of the person with allergies.

6. Make sure your house is cleaned regularly.

In your group, discuss the options in the list. For example,

What can you do today?
What will be the first things to change to control dustmites?
What options work for most of the people in your group?

Report your findings to the large group.

Mold Questions

Answer these questions about mold as a group. Discuss with each other why you think the answers you chose are correct.

Circle the answer your group believes is correct. Be prepared to defend you answer.

1. Only people with allergies are affected by mold, so if you don't have anyone with mold in your family, you don't have to worry about it.
   a. True
   b. False

2. To find out if you have mold in your house, you must pay an expert to analyze a sample of the area in your home that you think is mold.
   a. True
   b. False

3. Mold has a distinct odor so you will always smell it if it is there.
   a. True
   b. False

4. Name five things you should do to protect yourself when cleaning up mold.
   1.
   2.
   3.
   4.
   5.

5. Name the three things that mold needs to grow.
   1.
   2.
   3.

6. Mold has an important function on the earth. What is it?

IAQ Research Study – **University of Minnesota** (Cheple, Bruin, Yust)

House Review Start date ________________________

Unit address: ____Apt.__________

Name: ____________________________________Phone:_________________

Available time: __________________________________

Square foot __________

Bedrooms ___________

Number of occupants _____________

Hobo number/location ____

CO2 Yes No Location _______________________________________

VOC Yes No Location _______________________________________

Pick up date for VOC ____________________________

INTERIOR REVIEW

Condensation on:

_____ Windows

_____ Walls

_____ Other ___________________

Temperature at visit ______________

Relative humidity at visit ____________

Windows opened Yes No Location(s) ______________________________

Window coverings Yes No Type __________________________________

Signs of Mold:

Under sinks ______________________

Walls ______________________

Closets ______________________

Bathroom ______________________

Other ______________________

Bathroom fan:
Working on both speeds? Yes No
Rated CFM@ low speed ________high speed____________
Measured CFM@ low speed ________high speed____________

Kitchen fan:
Working on all speeds? Yes No
Rated CFM ______________
Measured CFM ______________

Notes:

Appendix I. HOBO Information for Participants

Dear Research Participant,

The HOBO equipment in your home is scheduled to begin collecting temperature and relative humidity levels on March 15, 2010 at 12AM. At that time, the small red light on the side of the HOBO will begin flashing.

If you do not see flashing of this red light, please notify Marilou Cheple at 651-246-1168. We will come to your home and replace the equipment with one that is working properly. This is a very important part of the research. Please let us know if the light stops flashing at any time during the three months it will be in place.

Again, thank you for your participation in this research.

The Research Team

Appendix J. Final Pickup and Acknowledgement of Gift Card Receipt

Dear Research Participant,

We want to thank you for participating in the Indoor Air Quality Research Project. Because you have completed all of the items requested of you, you are now receiving Target gift cards with a value of $80. These cards complete the $100 of Target cards for your participation in this project.

The results of the research will be available in approximately six months. If you would like to receive a report of the study, please notify Marilyn Bruin at 612-624-3780.

Again, thank you for your participation in this research.

Marilou Cheple, PhD Candidate
Marilyn Bruin, PhD
Becky Yust, PhD

I have received a total of $100 in Target cards for my participation in the Indoor Air Quality Study.

Name ____

Address ____

Phone ____

Date ____