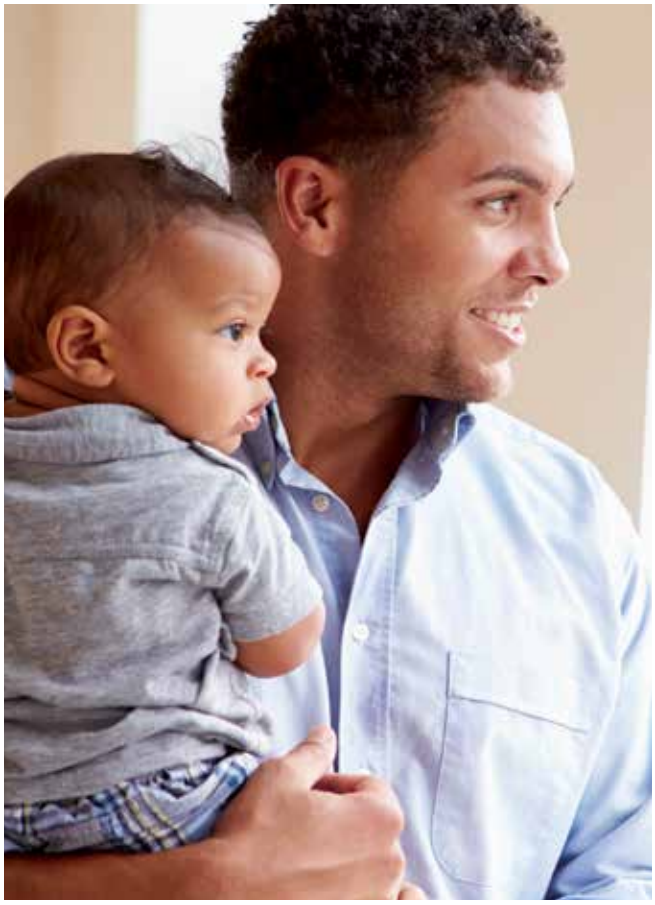
Weatherization and its Impact on Occupant Health Outcomes

Green & Healthy Homes Initiative®



Background

Low-income families occupy many of the 30 million structurally damaged houses in the U.S., which expose residents to hazardous environmental conditions that negatively impact their health:[1] low indoor air quality; poor movement of heat and moisture; radon; slips/trips and falls; dust mites; tobacco smoke and fires.[2]

The health effects most commonly linked to poor housing conditions are respiratory symptoms; asthma; lung cancer; depression and anxiety; injury or death from fires or accidents; hypothermia; and skin and eye irritation.[3] Young children and older adults (aged 65 and older) are at greatest risk, as they spend a larger proportion of their time in the home compared to working age adults.

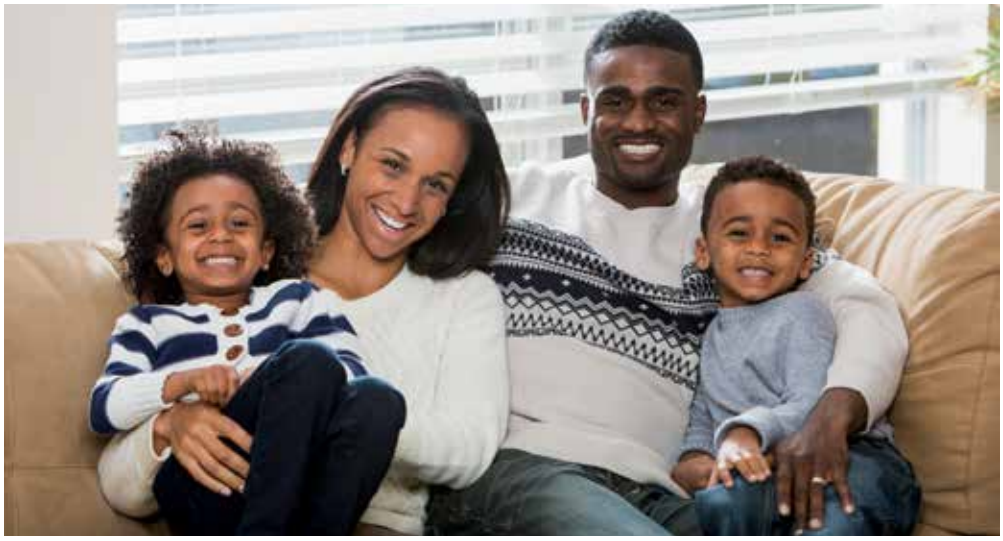
Weatherization services, like those provided to low-income households by the Weatherization Assistance Program (WAP), provide improvements that lower energy consumption and increase overall energy efficiency. At the same time these multicomponent weatherization services also produce non-energy benefits that address many health issues by remediating the hazardous environmental conditions that cause or are associated with negative health outcomes. The following report highlights the common environmental hazards present in poor quality housing that cause disease or exacerbate pre-existing health conditions, and demonstrates how weatherization and energy efficiency interventions can effectively mitigate them.

Multicomponent weatherization services also produce non-energy benefits that address many health issues by rectifying the poor housing conditions that cause or exacerbate them.

Investments in community-based programs that provide energy efficiency, weatherization or other integrated housing interventions generate non-energy benefits related to improvements in housing stability, affordability and quality of low income housing. International Energy Agency defines non-energy benefits, or multiple benefits, as "the wider socio-economic outcomes that can arise from energy efficiency improvement, aside from energy savings".[4] A social ecological framework is utilized to show the conceptual pathways linking non-energy benefits to multiple factors underlying the social determinants of health (SDOH). This brief is based on a larger working paper that performed a comprehensive search of peer-review articles from 2000 to 2016 and summarizes findings on how energy efficiency investments in the weatherization of low-income households impacts occupant health outcomes.

Link between Energy Efficiency and Weatherization and Social Determinants of Health

The link between housing and social determinants of health are known to include three inter-related aspects: conditions of the home environment, conditions of the neighborhood and housing affordability, which also affects the overall ability of families to make healthy choices.[5] Within the U.S. low income communities are frequently severely deficient in at least one, if not all, of the key domains of SDOH. Furthermore, the occurrence of a deficiency in one key area negatively affects standing in another. The built environments of poor neighborhoods tend to concentrate the negative externalities related to substandard housing, which in turn increases residents' risk of exposure to energy insecurity, fuel poverty, health and safety hazards, which cumulatively contribute to social inequalities of health. Extensive research into population health has consistently demonstrated the association between health status and socioeconomic status across the social gradient showing that the most advantaged in society have better health status, and the least advantaged are more likely to have worse health status. Even in the US, low socioeconomic status often means poor education, lack of amenities, unemployment and job insecurity, poor working conditions and unsafe neighborhoods.[6] Poor quality housing also exposes residents to health and safety hazards that can cause new incidences of disease or exacerbate pre-existing health conditions, in addition to individual costs and negative societal outcomes. Hazards include threats to fire safety, thermal discomfort from extreme temperatures, poor indoor air quality (IAQ), and environmental toxins. The health outcomes most commonly linked to these hazards include fire-related injury or



The built environments of poor neighborhoods tend to concentrate the negative externalities related to substandard housing, which in turn increases residents' risk of exposure to energy insecurity, fuel poverty, health and safety hazards, resulting in social inequalities of health.

SOCIAL DETERMINANTS OF HEALTH

Economic Stability	Poverty, employment, food security, and housing stability.
Education	HS graduation; enrollment in higher education; language/ literacy; early childhood education and development.
Social and Community Context	Social cohesion, civic participation, perceptions of discrimination and equity, and incarceration/institutionalization.
Health and Health Care	Access to health care, access to primary care and health literacy.
Neighborhood and Built Environment	Access to healthy foods, quality of housing, crime and violence, and environmental conditions.

death, cardio-vascular disease (CVD), respiratory symptoms, asthma, lung cancer, poor mental health, and skin irritation.[7] Poor urban populations are at particular risk because a significant proportion of urban housing is older and high density (such as row housing or multifamily units). Investments in energy efficient, safe, affordable housing for low-income communities can be directed to re-establish social equity in health by reducing the excess of housing and energy burdens experienced by these populations.

The eco-social theory of the distribution of disease maintains social conditions generate population distribution of disease and social inequalities in health. "Social inequalities (or inequities) in health refer to health disparities within or between countries that are unfair, unjust, unavoidable, and unnecessary (neither inevitable nor un-remediable) and that systematically burdens populations rendered vulnerable by underlying social structures".[8] Since health outcomes are in part generated by social conditions, such as housing affordability and quality, we find it necessary to establish a framework showing the non-energy benefits pathway to impacts on SDOH. Non-energy benefits, in fact, influence both the affordability of housing by reducing the energy cost burden, and the quality of housing that generates greater social equity in health by providing environmental, economic and health benefits for the occupant, owner, local community and region.[9] The following sections provide descriptions of the pathways where there is strong evidence of a causal association between the home health hazard, health outcomes, Healthy People 2020 objectives and long term impact on social determinants of health of the occupants. All of these health hazards are preventable by implementing standardized home remediation activities that follow the best practices of weatherization and healthy homes.

NON-ENERGY BENEFITS LINKED TO SOCIAL DETERMINANTS OF HEALTH

Inputs

COMPREHENSIVE HOUSING INTERVENTION

Energy Efficiency
Weatherization
Healthy Homes

Direct Energy Outputs

Change in kWh supplied

Change in kWh consumed

Energy Benefits

Reduce energy demand

Demonstrate leadership

Non Energy Outputs

Air Quality

Reduce criteria air pollutants

Reduce GHG emission

Health

Improved fire safety

Thermal comfort

Better Indoor air quality

Reduced environmental toxins

Ecomonic

Displacements savings from energy cost and waste heat

Program costs

Sector transfers

Non Energy Benefits

Environmental

Reduce GHG

Improve IAQ

Direct Occupant Health

Changes in incidences of:
Mortality

Hospital admissions

Upper & lower respiratory illness

Asthma/COPD

Lead poisoning

Cancer

Skin and eye irratation

Cardio-vascular disease

Depression and anxiety

Macro-Economic

Employment

Gross state product

Economic output & growth

Personal income/savings

Direct Economic

Individual:
Reduce energy cost

Reduce reliance on energy assistance programs

Reduce risk of eviction

Community:
Increase home values

Preserve affordable units

Long Term Impacts

Neighborhood & Built Environment

Quality of housing

Environmental conditions

Crime and violence

Health & Health Care

Access to health care

Access to primary care and health literacy

Social & Community

Social cohesion

Civic participation

Perceptions of discrimination and equity

Incarceration/institutionalization

Education

Early childhood education and development

School attendance

Economic Stability

Poverty

Employment

Housing stability

Thermal Stress

HAZARDS AND HEALTH EFFECTS

Thermal comfort is an individual's subjective satisfaction with their indoor climate. Thermal stress happens when thermal comfort is extremely diminished, either by extreme heat or cold. Exposure can be detrimental to people with preexisting conditions, and can cause death directly. Several studies have found correlations between heat waves and increased mortality for individuals with cardiovascular disease.[10] During the 2003 European heat wave, the mortality rate for people with cardiovascular disease (CVD) increased by 30 percent.[11] Furthermore, those with diabetes suffer more during heat waves, as their ability to regulate their body temperature is compromised by thermal stress.[12] Similarly, cold episodes have been shown to increase the rate of CVD emergency room (ER) visits for those with a history of cardiac disease or kidney disease, compared to those without these conditions.[13]

Several studies have found correlations between heat waves and increased mortality for individuals with cardiovascular disease.

Heating, ventilation and air conditioning (HVAC) systems are standard equipment in most U.S. homes, to improve thermal comfort for occupants. Poorly maintained systems, however, can allow dangerous organisms and grow on cooling coils and humidification components, exposing household occupants to hazardous pollutants.[14] The high moisture content of HVAC components makes them suitable breeding grounds for various contaminants, which are then disseminated throughout the building through the ventilation system. These contaminants include bacteria, molds, mildew, viruses, pollen and animal dander.[15] One hazard that has been consistently linked to HVAC wet cooling systems is Legionnaire's Disease – pneumonia caused by the bacterium Legionella pneumophila.[16] Legionnaire pneumophila is a climate related bacteria that grows in water

Climate change is predicted to increase the frequency and potency of extreme weather events.

THERMAL STRESS

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization **Insulation:** Improve home's insulation **Ventilation:** Increase the volume of indoor to outdoor air exchanged **Healthy Homes** Education on HVAC maintenance protocols	**Thermal Comfort** Improved indoor climate	**Lower Incidence of** Thermal stress related CVD emergency room visits and hospitalizations Thermal stress related hospitalization and death	**HDS-2** Reduce coronary heart disease deaths	**Neighborhood & Built Environment** Quality of housing Environmental conditions **Health & Health Care** Access to primary care and health literacy

after periods of high heat, rainfall and humidity. During heat waves, HVAC cooling towers used in large buildings, such as industrial buildings, hotels, and large multifamily units, can be breeding grounds for this bacteria and help spread the disease throughout buildings.

Climate change is predicted to increase the frequency and potency of extreme weather events. Records show that the global mean temperature during the 21st century's first decade was 0.8°C (1.4°F) higher than the 20th century's first decade. The increase in global temperature has been correlated with more reports of prolonged heat waves and shorter more intense cold spells.[17] As a result, climate change is predicted to increase the risk of thermal stress and thermal stress induced illness. Furthermore, the prevalence and incidence of climate related diseases have the potential to increase and appear in atypical countries or regions.

HVAC repairs and replacements conducted during weatherization renovations are the most effective method of tackling heat related thermal stress and reducing the growth of dangerous bacteria inside HVACs.

WEATHERIZATION SOLUTIONS

HVAC repairs and replacements conducted during weatherization renovations are the most effective method of tackling heat related thermal stress and reducing the growth of dangerous bacteria inside HVACs.[18] Additionally, installing heat reflective roofing allows buildings to better regulate indoor temperatures during heat waves. Weatherization interventions, such as air sealing building envelopes and insulation, which reduce heat seepage, are the most effective means of mitigating cold stress related mortality and morbidity. Reducing thermal stress not only would reduce the incidence of heat and cold related mortality and morbidity, it would also confer substantial savings for individuals and society. Oak Ridge National Laboratory calculated that WAP program repairs generate $870 in thermal heat stress benefits and $3,911 in thermal cold stress benefits per unit weatherized.[19] Another WAP evaluation calculated that after the first year, homes weatherized in 2008 produce over $122,000 and $153,000 worth of benefits from reducing heat-related and cold-related medical costs, respectively.[20] HVAC repairs coupled with regular maintenance and cleaning also tackles climate related diseases like Legionnaires because they stop the bacteria from reproducing.[21]

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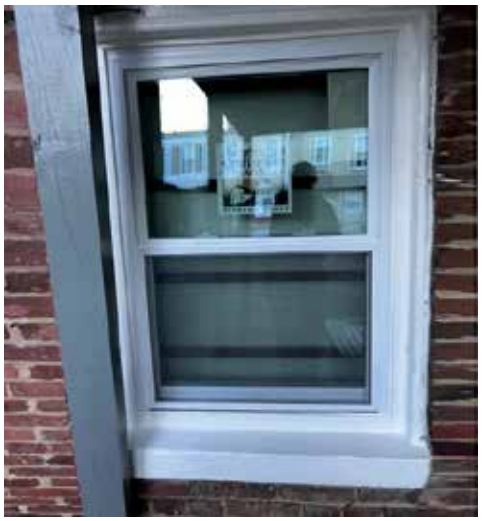

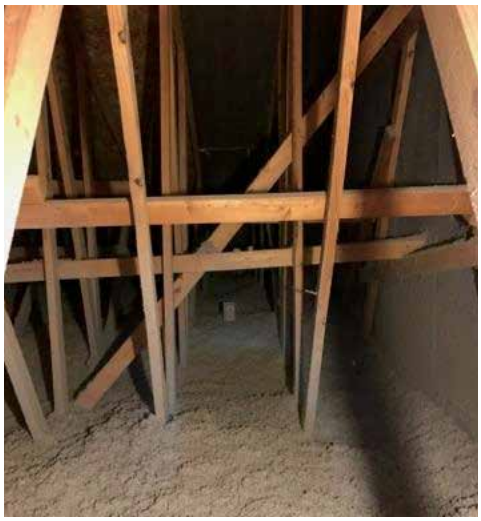

Installment of energy efficient windows and insulation lowers energy bills while also improving home comfort and occupant health.

Indoor Air Quality

HAZARDS AND HEALTH EFFECTS

Combustion gases are a critical source of indoor air pollution. Household combustion appliances, such as unvented gas stoves, heaters, furnaces, and wood-burners, are the primary sources of these home contaminants, including carbon monoxide (CO), aldehydes, sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM) and other hydrocarbons. However, with poor ventilation the gases can also seep in from outdoor sources and concentrate at higher levels indoors. While acute high level CO exposure can cause death, low level prolonged exposure is associated with fatigue, dizziness, and carboxyhemoglobin.[23] In the U.S., CO poisoning causes approximately 15,000 ER visits and nearly 450 deaths annually (64 percent occurring in the home) and is the leading cause of unintentional poisoning deaths.[24,25] Evidence shows that long term NO_2 exposure may decrease lung function and increase the risk for respiratory symptoms.[26] Although researchers found no health effects for NO_2 exposure below 0.2ppm (parts per million), indoor NO_2 can range between 0.4-1.5ppm.[27] PM exposure is linked to increasing morbidities and mortalities of CVD and Pulmonary Disease.[28] Furthermore, PM can attach to other dangerous gases (i.e. radon), which exposes residents to further health hazards.

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COMBUSTION GASES AND VENTILATION

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization **Source Control:** Removal of all unvented combustion space heaters Repair/replace unvented heat pumps, vented gas heating, or enclosed wood burners **Ventilation:** Increases the volume of indoor to outdoor air exchanged **Healthy Homes** Install CO monitors in homes with combustion appliances	**Better Indoor Air Quality** Reduced concentration of poly-cyclical aromatic aromatic hydrocarbons (PAH), hydrocarbons, aldehydes, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM) in the home	**Lower Incidence of** CVD related emergency room visits Adverse respiratory symptoms COPD CO poisoning hospitalization and death	**EH-22.7** Increase states that monitor diseases or conditions that can be caused by acute exposure to CO poisoning **HDS-2** Reduce coronary heart disease deaths **RD-1-13** Respiratory diseases	**Neighborhood & Built Environment** Quality of housing Environmental conditions **Economic Stability** Poverty Employment

Radon exposure is the second biggest risk factor for lung cancer after exposure to tobacco smoke.[29] Radon emanates from the ground through natural or man-made pores, allowing it to seep into water or gas piping, enter the home and compromise IAQ.[30] The risk for radon exposure varies according to geography; and it is primarily absorbed through the skin or inhaled along with PM.[31] *Turner et al.* analyzed the residential radon levels of 1.2 million individuals through 1988 and found, after controlling for demographic characteristics, a 15 percent increase in the risk for lung cancer mortality per 100 Bq/m3 increase in radon.[32] Depending on a country's radon level, radon exposure is estimated to cause between 3 and 14 percent of all lung cancers.[33]

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RADON

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization Cover exposed ground in the homes (i.e. basements) with a vapor barrier Make HVAC units ASHRAE compliant Install radon mitigation system	**Better Indoor Air Quality** Drop in radon levels in all levels of the home	**Lower Incidence of** Radon attributable lung cancer cases	**EH-14** Increase the proportion of homes with an operating radon mitigation system for persons living in homes at risk for radon exposure **C-2** Reduce the lung cancer death rate	**Neighborhood & Built Environment** Quality of housing Environmental conditions

Volatile organic compounds (VOCs), carbon-based chemicals that evaporate at room temperature, are common sources of indoor air pollution. Formaldehyde, acetaldehyde, benzene, and toluene are common VOCs and can radiate from building materials.[34] The EPA has found concentrations of VOCs to be 2 to 5 times higher indoors than outdoors.[35] Formaldehyde exposure is the focus of most VOC research. Acute formaldehyde exposure can lead to nose, throat, eyes, or skin irritation, whereas chronic exposure can lead to similar but more severe symptoms in addition to headaches, memory loss, sleep disorders, dizziness, and neurological diseases. Over time, formaldehyde exposure can lead to decreased white blood cells, platelets, and hemoglobin counts.[36] The International Agency for Research on Cancer has classified formaldehyde as a carcinogen that can cause nasopharyngeal[i] cancer in people who were exposed to unusually high concentrations. Some scientists have also tied formaldehyde to leukemia.[37]

Acute formaldehyde exposure can lead to nose, throat, eyes, or skin irritation whereas chronic exposure can lead to similar but more severe symptoms in addition to headaches, memory loss, sleep disorders, dizziness, and neurological diseases

VOLATILE ORGANIC COMPOUNDS, FORMALDEHYDE, AND AIR POLLUTANTS

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization Removal of VOCs emitting materials and products **Healthy Homes** Education on how to reduce VOC exposure	**Better Indoor Air Quality** Lower levels of ambient VOCs in the home	**Lower Incidence of** Skin and eye irratation Asthma symptoms Pulmonary damage Amyotrophic lateral sclerosis (ALS), VOC related headaches, memory loss, sleep disorders, dizziness, and neurological diseases with aging.	**EH-11** Reduce the amount of toxic pollutants released into the environment	**Neighborhood & Built Environment** Quality of housing Environmental conditions **Education** School attendance **Health and Health Care** Access to primary care and health literacy

[i]Upper Throat and Nose

WEATHERIZATION SOLUTIONS

CO monitoring devices installed during weatherization retrofits have been shown to prevent CO-associated ER visits, hospitalizations and 65 percent of CO deaths in homes with combustion appliances.[38] Appliances that produce combustion gases should be replaced with vented appliances, whereas VOC emitting products or building materials should be removed and replaced with safer alternatives. HVAC installations conducted during WAP renovations are also a cost-effective means of improving IAQ, as systems ventilate combustion gases and VOCs from the home. Additionally, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standards compliant HVACs have been shown to reduce indoor radon by 12 percent on average.[39] Many of the same weatherization interventions used to prevent dampness and water infiltration in flood prone area homes can be used to fortify buildings against radon. However, WAP providers must ensure that weatherization measures, such as air sealing building envelopes, do not inhibit radon from escaping the home.[40]

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Biological and Unsanitary Conditions

HAZARDS AND HEALTH EFFECTS

Structural leaks, damp foundations and inadequate ventilation are common issues present in poor quality housing. These deficits can lead to unsanitary conditions such as the presence of different combinations of bacteria, molds, viruses, dust mites and pest infestations, all of which can cause serious health problems for occupants. Early postnatal exposure to mold spores can compromise infant respiratory system development.[41] The Institute of Medicine has also found evidence linking damp indoor environments to respiratory illness in otherwise healthy children and risk of asthma in

The Institute of Medicine has also found evidence linking damp indoor environments to respiratory illness in otherwise healthy children and risk of asthma in susceptible individuals.

BIOLOGICAL AND UNSANITARY HOUSING CONDITIONS

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization Remove moldy objects from home Repair moisture intrusion points Repair/Improve home HVAC systems Improve home insulation Exterior repairs to downspouts, gutters, and grading to reduce water infiltration **Healthy Homes** Distribute allergen impermeable bedding Education on cleaning and washing protocols for furnishing and floors Use of dehumidifiers Removal of carpets Roof repair or replacement	**Reduced Environmental Toxins** Reduce the number of dust mites Lower levels of surface and ambient mold Lower levels of surface and ambient bacteria	**Lower Incidence of** Asthma symptom days Asthma-related school and work absences Allergic reactions Asthma genesis Upper and lower respiratory illness Hospital admissions and emergency department visits	**RD-1-6** Respiratory diseases **EH-19** Reduce the number of occupied housing units that have moderate or severe physical problems	**Neighborhood & Built Environment** Quality of housing Environmental conditions **Education** Early childhood education and development School attendance **Health and Health Care** Access to primary care and health literacy

susceptible individuals.[42] Dust mites, frequently found in bedding and carpets, thrive in humid climates and are conduits for lead and other contaminants.[43] Moreover, the National Academy of Sciences recently found a causal association between dust mite allergen exposure and asthma.[44] Pests (e.g. rodents and cockroaches) are prominent sources of indoor allergens and an indication of unsanitary living conditions. Inhaled pest excrements, cockroach and mouse dander can result in allergic reactions and are a leading cause of asthma exacerbations and contribute to high asthma hospitalization rates among asthmatic children.[45] Additionally, vector-borne rodent diseases, such as the often fatal Hantavirus cardiopulmonary syndrome, are easily transmitted through bites and fleas.[46]

WEATHERIZATION SOLUTIONS

Multifaceted, multicomponent interventions, including home environmental assessments, in home education, allergen-impermeable bedding distribution, home repairs, HVAC improvement[ii] and integrated pest management (IPM), were found to reduce asthma morbidity and respiratory allergies.[47] A study analyzing the effects of home interventions that included HVAC system repairs found that the intervention reduced asthmatic morbidity, and significantly decreased symptom days.[48] Installing a whole-house mechanical HVAC system can reduce the moisture and humidity in a home, which in turn, reduces dust mite numbers, and decreases allergen levels.[49] In temperate climates, dehumidifying rooms to below 60 percent has been shown to be particularly effective in reducing dust mite levels.[50] Allergen-impermeable bedding, in addition to frequent cleaning, has also been shown to remove dust mites from the home.[51] IPM strategies typically include filling pest infiltration holes, vacuuming, cleaning surfaces, sealing trash, placing traps and minimizing access to food sources.[52] A 2009 study that compared IPM interventions in buildings with those that used more traditional measures of pest control over 6 months, found that the IPM treated buildings reported lower levels of cockroach allergens compared to the control group.[53]

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[ii]high-efficiency particulate air-filtration (HEPA) filters or whole system installation

Fire Safety

HAZARDS AND HEALTH EFFECTS

Residential injuries account for thousands of deaths and hospitalizations annually, of which fires are a notable cause.[54] Between 2011 and 2013, 372,900 residential fires were reported to U.S. fire departments annually, and were estimated to cause 2,530 deaths, over 13,000 injuries and approximately $7 billion in property damage.[55] Faulty electrical wiring, defective appliances, overloaded circuits, malfunctioning heating systems and lighting equipment are common fire hazards. Substandard housing frequently contains many of these fire hazards, and is also less likely to contain smoke detectors or CO monitors, which leaves residents at higher risk for injury.[56] A systematic review of safety and injury orientated housing interventions found that homes with working smoke alarms have a 40-50 percent lower death rate than homes without working smoke alarms.[57,58] Another study found that 70 percent of deaths related to home fires occurred in homes without functional smoke alarms.[59]

WEATHERIZATION SOLUTIONS

Evidence indicates that smoke detectors installed during weatherization drastically reduce fire related injuries and mortality, especially when coupled with education on how to maintain installed smoke detectors. Additionally, many weatherization interventions repair malfunctioning appliances, wiring and heating systems, thereby removing common fire hazards from the home.

FIRE SAFETY

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Weatherization Repair faulty wiring Installing smoke detectors	**Reduced Environmental Toxins** Reduced fire hazards in the home	**Lower Incidence of** Fire-related injuries Fire-related hospital admissions Fire-related deaths	**Unintentional Injury Prevention IVP-28** Reduce residential fire deaths	**Neighborhood & Built Environment** Quality of housing Environmental conditions

Lead

HAZARDS AND HEALTH EFFECTS

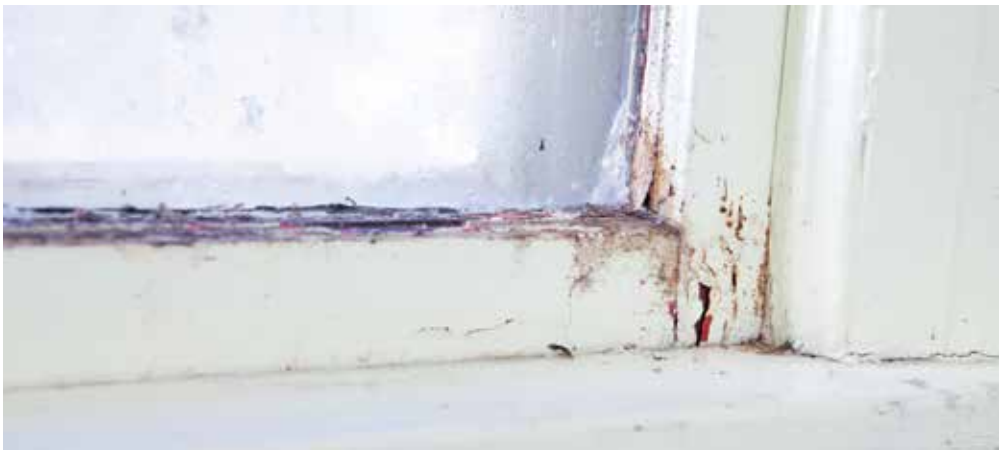
Lead toxicity presents serious health issues to humans. Major lead hazards include paints, water, dust, soil, kitchen utensils and leaded gasoline.[60] The U.S. did not ban lead paint for residential use until 1978. Therefore older homes, which constitute the majority of low-income housing, are at greater risk of containing lead paint. Children are often poisoned after ingesting lead paint chips or inhaling lead dust in their homes. Adults are more likely to inhale lead from sources outside the home.[61] Lead severely damages blood cells, the nervous system, the reproductive systems and the kidneys.[62] Lead poisoning is especially detrimental for children and can cause: "hyperactivity, anorexia, decreased play activity, low intelligence quotient and poor school performance".[63] In 2012 the Center for Disease Control and Prevention lowered its classification of elevated blood lead level (BLL) from ≥ 10 µg/dl to ≥5µg/dl, but stressed there is no safe BLL.[64]

LEAD-BASED PAINT/LEAD-SAFE WEATHERIZATION PRACTICES

Home Intervention	Output	Outcome	Healthy People 2020 Indicator	Social Determinants of Health
Lead Abatement Encapsulation (covering lead paints with a neutral paint barrier), Enclosure (covering paint with a rigid barrier) Window replacement and/or window treatments **Healthy Homes** Education on lead safety practices maintenance and repair protocols	**Reduced Environmental Toxins** Lower levels of lead dust and/or chips found in the home	**Lower Incidence of** Childhood lead poisoning	**EH-8** Reduce the blood lead levels in children **EH-17** Increase the proportion of persons living in pre-1978 housing that has been tested for the presence of lead-based paint or related hazards **EH-18** Reduce the number of US homes that are found to have lead-based paint **EH-20.3** Reduce exposure to lead in the population	**Neighborhood & Built Environment** Quality of housing Environmental conditions Crime and violence **Education:** Early childhood education and development School attendence

WEATHERIZATION SOLUTIONS

The majority of the health effects caused by lead poisoning are irreversible, therefore early intervention is key. Lead abatement is occasionally performed alongside WAP services and frequently involves covering lead paints with a neutral paint barrier (encapsulation), a rigid barrier (enclosure), window replacement and/or window treatments.[65] An evaluation of the 1993/1994 HUD Lead Hazard Control Grant program, which utilized the aforementioned lead prevention measures, found that children's BLL fell at every successive test period—6 months, 1 year, 2 years and 3 year post intervention.[66] A 12 year post intervention follow up study found homes that replaced all of their windows had 41 percent lower interior floor lead dust and 51 percent lower window sill lead dust compared to homes with non-replacement.[67] WAP services, without direct lead abatement, still lowers the risk of lead poisoning. Certain weatherization interventions, such as moisture control, air sealing and improved ventilation improves paint stabilization and protects homes that contain lead-based paint against chipping paint.



Replacement of windows with lead-based paint hazards (above) with new energy efficient windows (below) reduces exposure to lead contaminated dust and prevents lead poisoning.

Conclusion

Traditionally, state energy efficiency programs either do not include health-related non-energy benefits in their program cost-effectiveness evaluations, or only valuate a small selection of "easy-to-measure" variables.

This practice can jeopardize home-based energy programs' funding because states underestimate their entire cost-effectiveness. Recently, public healthcare policy has shifted from traditional clinical care approaches toward a more holistic approach that focuses on a population's environment. Furthermore, population health research using best possible estimates shows person's social circumstance (15 %), behavioral patterns (40%) and environmental exposures (5%) are responsible for up to 60 percent of their health outcomes.[68] As a result, more health systems, hospitals, and managed care providers are investing in social services that tackle the forementioned social determinants of health in addition to traditional clinical care.

A shift towards a community-based approach to health care and growing evidence base of research on social determinants of health have created strong grounds for using weatherization and other home-based environmental interventions to tackle prominent health inequities. At the same time there is a need to incorporate public health goals, such as National Prevention Strategy Healthy People 2020 objectives, into program evaluation plans and fund the scaling of cost-effective integrated housing interventions (health and energy). The coordination of policies, programs and services will increase opportunities to achieve goals from both the fields of public health and affordable multifamily housing. Aligning goals across sectors and evaluating measurable objectives can serve as the impetus for further collaboration between state health departments, Medicaid providers, weatherization agencies and other community-based organizations. Collaboration and data sharing between these entities could target the identification of vulnerable persons with health conditions that would benefit from weatherization and remove barriers to tracking and accurately valuing health outcomes.

The evidence presented clearly demonstrates that weatherization interventions not only provide a path to lower energy costs but can also generate non-energy benefits that have a notable impact on health outcomes.

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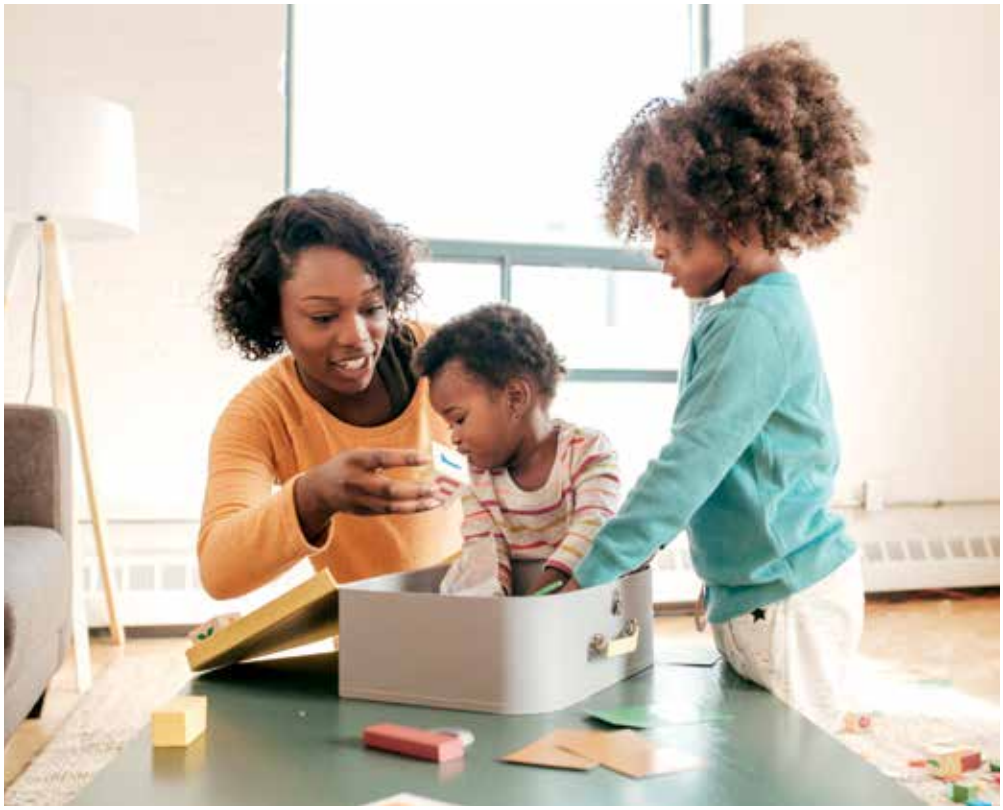

The Green & Healthy Homes Initiative (GHHI) is dedicated to breaking the link between unhealthy housing and unhealthy children.

Footnotes

[1] US Department of Housing and Urban Development, "Advancing Healthy Housing: A Strategy for Action" (2013)Retrieved March 30, 2013, from:http://portal.hud.gov/hudportal/documents/huddoc?id=AHHASA_2-19.pdf

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[3] *Ibid*

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[5] Craig Pollack, Susan Egerter, TabashirSadegh-Nobar, Mercedes Dekkerand Paula Braveman"Where We Live Matters or Our Health: The Links Between Housing and Health" *Robert Wood Johnson Foundation* (2008)

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