MAKING HEALTH COUNT:

Monetizing the Health Benefits of In-Home Services Delivered by Energy Efficiency Programs

Sara Hayes, Cassandra Kubes, and Christine Gerbode

RESEARCH REPORT
MAY 2020

ACEEE
American Council for an Energy-Efficient Economy

Contents

About the Authors

Sara Hayes manages the Health and Environment Program at ACEEE. She oversees a research team focused on strategies and opportunities to use energy efficiency to reduce pollution and improve human health. Sara is a licensed attorney in the state of New York and serves on the Environmental Protection Agency's Clean Air Act Advisory Committee. She holds a JD from Fordham Law School and a bachelor of arts in environmental studies from Lewis and Clark College.

Cassandra Kubes conducted research, analysis, and outreach for ACEEE on the relationship between energy efficiency and public health. She holds a master of public policy from George Washington University and a bachelor of arts in people-environment geography from the University of Wisconsin–Madison.

Christine Gerbode conducts research at the intersection of energy use and human health. Her work helps decision makers and policy advocates use energy efficiency to protect health and ensure equity for vulnerable populations. She holds a master's degree in environmental management from Duke University and a bachelor of science in earth science from Rice University.

Acknowledgments

The authors gratefully acknowledge the support of external reviewers, internal reviewers, colleagues, and sponsors. This report was made possible through generous support from Southern California Edison, CenterPoint Energy, E4TheFuture, and ComEd. External expert reviewers were Scott Higa from Southern California Edison, Nick Mark from CenterPoint Energy, Erin Rose of Three3, and Ellen Tohn of Tohn Environmental Strategies. The authors also gratefully acknowledge the assistance of Bruce Tonn from Three3, who served as advisor to this project. External review and support do not imply affiliation or endorsement. We also thank our internal reviewers, Steven Nadel and Neal Elliott. Last, we would like to thank Karin Matchett and Fred Grossberg for developmental editing; Mary Robert Carter and Mariel Wolfson for managing the editorial process; Keri Schreiner, Sean O'Brien, and Roxanna Usher for copy editing; Kate Doughty for assistance with the graphics; and Ben Somberg, Maxine Chikumbo, and Wendy Koch for their help in launching this report into the world.

Suggested Citation

Hayes, S., C. Kubes, and C. Gerbode. 2020. *Making Health Count: Monetizing the Health Benefits of In-Home Services Delivered by Energy Efficiency Programs.* Washington, DC: American Council for an Energy-Efficient Economy. www.aceee.org/research-report/h2001.

Executive Summary

KEY TAKEAWAYS

- Energy efficiency programs bring both energy savings and the potential for substantial health benefits to participating households.
- The large existing network of in-home energy efficiency programs could be modified to include measures that promote better health outcomes for program participants.
- If existing weatherization programs targeted four common health risks—asthma, falls, and exposure to extreme heat or cold—they could save more than $228 million due to avoided health harms. Those savings could reach $2.9 billion over 10 years.
- Monetized estimates of the health benefits of interventions can be leveraged to enable programmatic changes, help to build partnerships between the energy efficiency and health sectors and attract additional funding for in-home efficiency programs.

Housing, health, and energy efficiency are closely intertwined. Power utilities and federal agencies invest billions of dollars every year in a nationwide network of in-home energy efficiency programs. These programs can also make homes healthier: They can enhance indoor air quality and general living conditions by improving ventilation, installing insulation, replacing inefficient or malfunctioning appliances and equipment, and sealing leaky doors and windows. These housing improvements can in turn mitigate serious health issues such as asthma, respiratory illness, and cardiovascular disease.

Thoughtfully designed and executed weatherization programs can have a direct positive impact not only on the physical health of program participants but also on their broader well-being through reductions in energy spending and health care costs. Low-income families are particularly vulnerable to chronic diseases like asthma and heart attacks; at the same time, they are disproportionately likely to live in physically inadequate housing and to pay high monthly energy bills. Weatherization programs can therefore have a large impact on quality of life for these vulnerable populations.

The passage of the Affordable Care Act of 2010 promotes a preventive rather than a reactive health care service model; the rationale behind this shift is that the costs of supporting preventive measures that avoid those harms are often much lower than the medical costs associated with treating illness and injury. This shift has created an opportunity to leverage the existing nationwide network of energy efficiency programs to significantly impact public health.

Folding in-home health services into energy efficiency program design can be a win–win for utilities, the health sector, vulnerable communities, and US households. In addition to potentially improving the health of program participants, joint program delivery can reduce transaction costs, serve a greater range of needs, and help both the energy and health sectors provide better services while using limited resources more effectively. It can also provide families with streamlined participation processes that more comprehensively address their needs. Together, these increased benefits and potential administrative efficiencies could increase both the number of people served and the value of services provided.

Although the relationships between improving the built environment and protecting health are increasingly recognized, it can be challenging to quantify these health impacts. Such a quantification is important, however, as it can build support for comprehensive program alignment from the utilities side, which often requires cost-effectiveness testing. Health care sector actors may also be more likely to support and fund blended services if the values and savings of doing so are clear. To help utilities, program administrators, public health advocates, health care professionals, and other decision makers understand the potential value of adding health services to weatherization programs, we provide simplified equations to estimate, quantify, and monetize the health outcomes of four specific in-home health interventions—aimed at reducing asthma, hypothermia, heat stress, and trip-and-fall injuries—that could be added to efficiency retrofitting programs.

We reviewed the literature and interviewed experts to develop a simplified estimation equation to calculate a range of potential cost savings in terms of the dollar value of avoided health care costs and mortality. The generalized formula is as follows:

> *Dollars saved due to avoided health harm* = *Number of households reached* x *Number of vulnerable occupants* x *Number of incidents or harms avoided through intervention* x *Dollar value of avoided health harm*

We also provide an appendix of literature and data resources for decision makers seeking to customize and tailor these calculations to their local program context.

By incorporating just four health-focused interventions into the existing network of energy efficiency programs, our estimates show substantial health benefits. As Table ES1 shows, after 1 year, these measures could prevent more than $228 million in health harms, while after 10 years the cumulative benefits of these interventions rise to $2.9 billion (assuming the same number of new participants is added to the program each year).

Table ES1. Monetized health benefit potential from select in-home interventions

	Nationwide total after one year	Nationwide total after 10 years
Reduced trip-and-fall injuries	$177,200,000	$2,180,000,000
Reduced asthma symptoms	$38,500,000	$593,000,000
Reduced heat-related thermal stress	$8,000,000	$73,000,000
Reduced cold-related thermal stress	$4,600,000	$41,000,000
Total monetized health benefits from four targeted interventions	$228,000,000	$2,888,000,000

These numbers are a fraction of what is possible, as they represent only a few selected benefits from the long list of health outcomes that might accrue to households participating in an in-home energy efficiency program. These figures also represent conservative estimates of potential impacts, as the populations most likely to utilize these programs belong disproportionately to the vulnerable groups at higher risk of these health harms.

We believe quantification and monetization of the potential values associated with comprehensive energy and health programs can help empower decision makers in both sectors to prioritize health investments in previously unfeasible contexts. Indeed, even presenting numbers on health costs in this context can help spark new conversations within and across sectors. This can help facilitate the health–energy partnerships needed to make comprehensive in-home health and energy programs a new standard—rather than an exception—moving forward. By quantifying the potential benefits of comprehensive cross-sector programs, we can help programs make their interventions count for more, while also helping administrators and funders count the true value they provide.

Housing, Health, and Energy

The passage of the Affordable Care Act of 2010 initiated a major transformation of the health care industry. Today, success in the medical sector is increasingly measured in terms of outcomes rather than the number of people receiving treatment, and shifting financial models increasingly reward a preventive, rather than reactionary, service model (CCIOO 2010). The medical costs associated with treating illness and injury are often much higher than avoiding those harms through preventive measures. For example, a single asthma-related emergency room visit can cost thousands of dollars, whereas preventively removing in-home triggers that lead to attacks likely cost less and can avoid that single visit and future visits as well.

Environmental conditions have a profound influence on health and well-being. Homes with poor structural and environmental conditions can contribute to a host of illnesses and medical symptoms for residents. Poorly sealed building envelopes can allow in pests, moisture, air pollution, and other stressors that can cause or exacerbate health problems. More than half of the US building stock is over 35 years old (Zhao 2017) and, in some cases, these older buildings were constructed with hazardous materials such as lead (EPA 2019) and asbestos (ATSDR 2016). Older homes are also more likely to contain malfunctioning building systems and equipment due to natural degradation and increased chances of deferred maintenance over time.

Inadequate housing is one of the social determinants of health that burden struggling individuals and families (Hernández 2016; CDC 2018). Low-income families living in unhealthy homes have disproportionately high rates of chronic diseases such as asthma, heart attacks, stroke, and high blood pressure (Census Bureau 2017; Brown 2012; Akinbami et al. 2012; Go et al. 2013; Oates et al. 2017). At the same time, homes with inefficient heating and cooling systems, poor insulation, and inadequate air sealing lead to high monthly energy bills. Housing, health, and energy efficiency are deeply intertwined. Millions of Americans living in unhealthy housing also struggle to meet their basic energy needs and often face a high energy burden—that is, high energy costs as a percentage of income—as a result of conditions in their homes (Drehobl and Ross 2016).[1] Further, low-income households of color experience higher energy burdens than the average household in the same city (Drehobl and Ross 2016).[2] Families experiencing high energy burdens and energy insecurity may face a choice between either meeting the family's needs for food and medicine or paying for electricity, gas, or fuel oil to heat or cool their home (Hernández 2016).

Energy Efficiency Services and Health Benefits

THE EXISTING NETWORK

Each year, electric and natural gas utilities invest billions of dollars in a nationwide network of energy efficiency programs. Utility program investment totaled approximately $8 billion

[1] *Energy burden* is a household's total annual energy spending (electric, gas, and/or other heating fuel) as a percentage of total annual gross income.

[2] The report defined *low-income households* as those with income at or below 80% of area median income.

in 2018; such programs are operated in every state and use contractor networks to perform in-home energy efficiency improvements (Berg et al. 2019).

In most states, utilities offer energy efficiency programs targeted to low-income households that are funded through ratepayer dollars (ACEEE 2019). Many of the utility programs offered to single-family, low-income households are whole-building retrofit programs, commonly known as *weatherization* programs (Cluett, Amann, and Ou 2016). The US Department of Energy (DOE) Weatherization Assistance Program (WAP) serves the most homes of any residential whole-house energy efficiency program in the United States and provides services for families who meet the income-eligibility requirements (DOE 2020). DOE awards WAP funding to state governments, which in turn contract with local agencies to deliver weatherization services in single-family and multifamily homes.

The WAP program offers many energy efficiency improvements including air sealing; insulation and upgrades to heating, ventilation, and air conditioning (HVAC) units; and more efficient lighting, appliances, and water heaters. The program also addresses a range of directly and tangentially related health and safety risks by installing smoke and carbon monoxide detectors, ensuring that combustion appliances and heating systems work properly, installing mechanical ventilation for improved indoor air quality, and identifying mold or moisture hazards (Cluett, Amann, and Ou 2016; DOE 2019). Utility energy efficiency programs often complement WAP services; in many states, utilities work with state and local agencies delivering WAP services to coordinate program funding, administration, and implementation (ACEEE 2019; Gilleo, Nowak, and Drehobl 2017).

WAP is not the only program model for serving low-income households. Other state- and community-level program models go beyond WAP's measures to deliver even more robust health interventions, providing numerous health benefits to families by improving housing conditions and reducing energy costs. These enhanced services can include mold remediation; removal of unhealthy carpets; asthma education and mitigation; trip-and-fall prevention; and asbestos, lead, and radon remediation (NCHH 2020).

THE HEALTH BENEFITS OF SAVING ENERGY

Energy efficiency programs can make people's homes healthier by improving ventilation, installing insulation, replacing inefficient or malfunctioning appliances and equipment, sealing leaky doors and windows, and improving indoor air quality. These efficiency measures reduce asthma triggers and other respiratory ailments, and they also reduce the risk of thermal stress (Hawkins et al. 2016). In-home programs may provide the greatest health benefits for low-income families and communities of color because these populations suffer disproportionately high rates of many of the illnesses and diseases that preventive measures address. By lowering financial stress through reduced energy and medical bills, in-home programs can also help vulnerable families avoid having to choose between necessities, as well as head off potentially cascading health impacts.

Figure 1 illustrates the benefits of energy efficiency for home occupants.

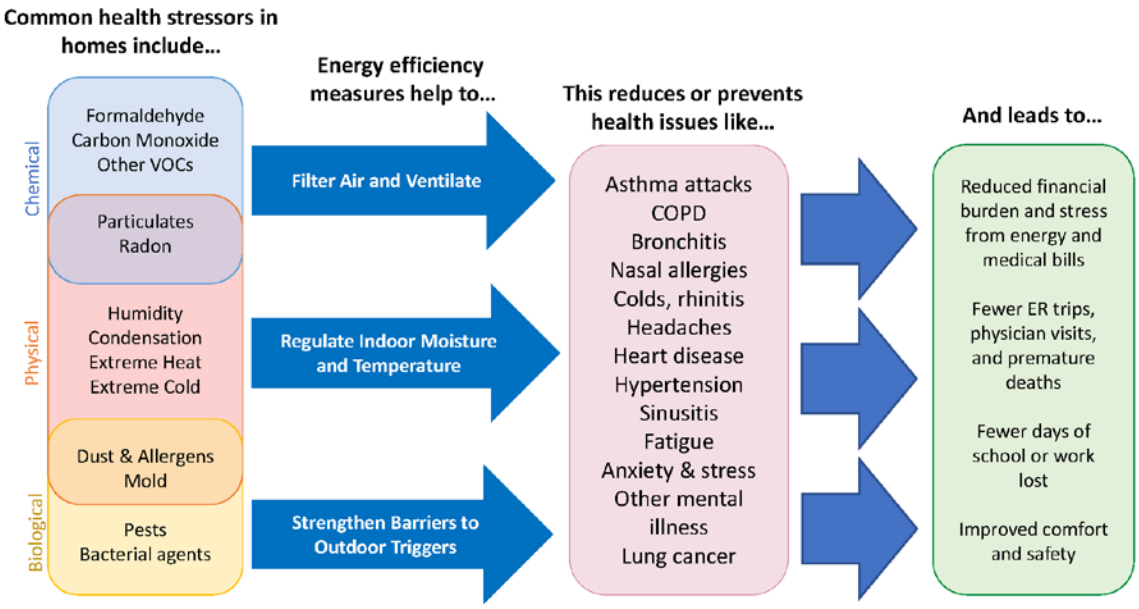

Figure 1. Health benefits from energy efficiency for home occupants. *Source:* ACEEE.

A New Channel to Deliver Preventive Health Services

It is well recognized that environmental conditions and changes to the built environment have major impacts on human health, and yet doctors, hospitals, and other public health professionals are rarely empowered with the resources to address these factors. Some programs exist to help households improve health, while others reduce energy costs, but rarely do programs target both goals at once.

The existing network of energy efficiency and weatherization programs offers a new channel for delivering preventive services outside of hospitals and clinics. Every family living in a home with electricity or natural gas service can potentially be reached through this expansive network. Communication channels with potential program participants already exist in the monthly bills they receive from utility providers, which have established relationships with building occupants.

Leveraging this network for public health can help program participants avoid injuries and save money. For example, the family of an asthmatic patient might receive in-home education to prepare them to respond to the patient's symptoms, while also receiving a home audit to identify asthma triggers that could be mitigated as part of an in-home energy-saving program. Older adults are particularly susceptible to health harms from extreme heat and cold, and from falls. An in-home program might provide insulation and air sealing, and replace or repair heating and cooling equipment, all of which will help to minimize exposures to extreme temperatures. And, while this work is being done, service providers can also reduce fall risks by improving or adding lighting and handrails, providing education, and removing trip hazards.

Some efforts are currently underway to bring together energy and health care dollars to provide comprehensive services, but most of these programs are in the pilot stage. There is

significant opportunity to take a more comprehensive approach to program delivery and to expand programs to include interventions that have a strong impact on health. Cross-sector partnerships can help meet public health needs through in-home preventive approaches; these partners might include utilities, energy efficiency providers, hospitals, insurers, managed care organizations, public health departments, health advocates, and community-based organizations.

Figure 2 outlines our theory of change and the conditions that will enable the health care and energy sectors to combine resources to preventively address the social determinants of health in the built environment.

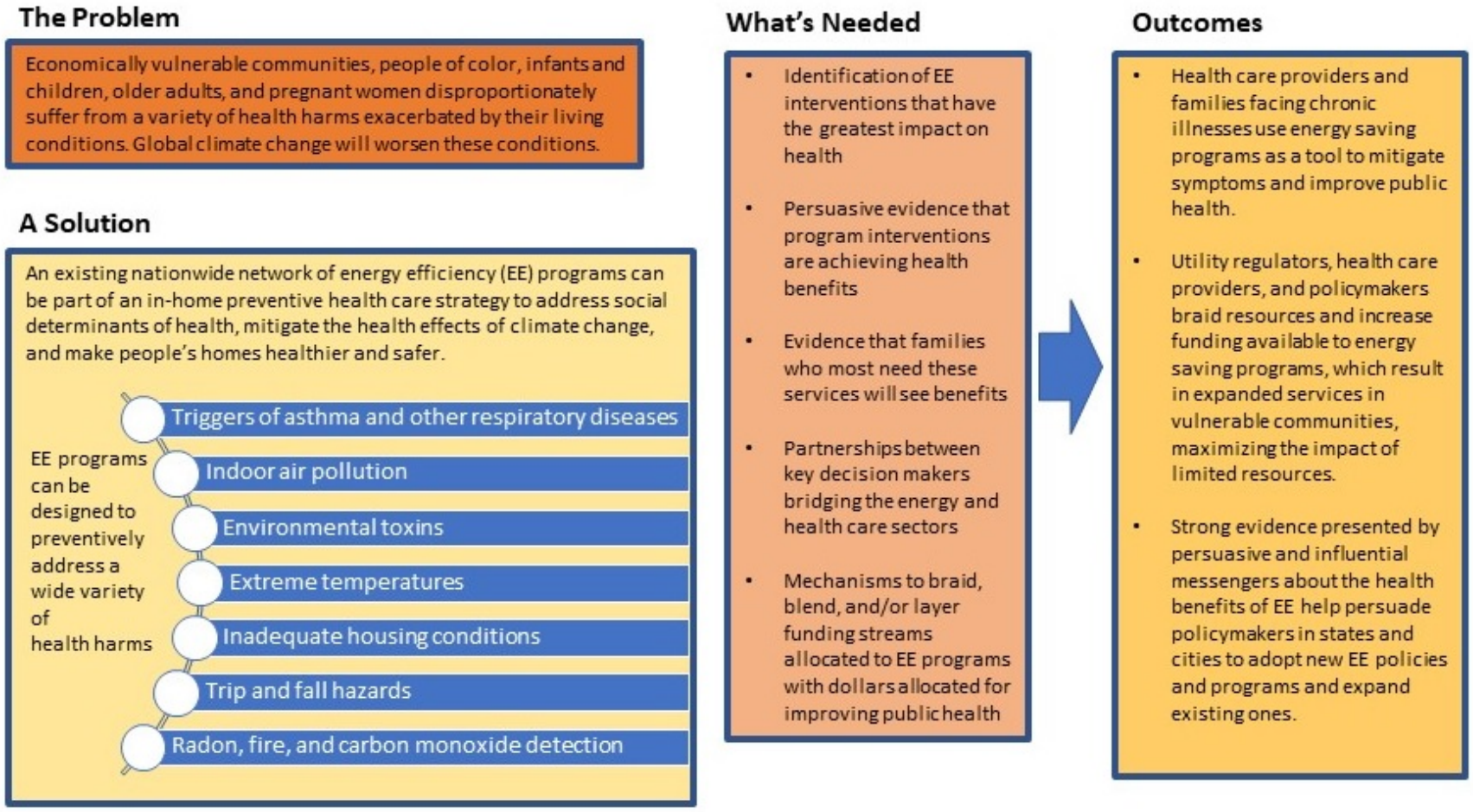

Figure 2. Theory of change for using energy efficiency network as an in-home preventive health care strategy

Benefits of Comprehensive Programs

Folding health services into energy efficiency program design can be a win–win for utilities, the health sector, vulnerable communities, and US households. In addition to having the potential to significantly improve program participant health, joint program delivery can reduce transaction costs and help both sectors provide better services and use their limited resources more effectively. It can also provide families with wraparound services that more comprehensively address their needs.

FUNDING

Joint programs can potentially attract additional partners and new streams of funding to support expanded services. A forthcoming ACEEE analysis identifies hundreds of millions of dollars in federal funding that could be combined with energy efficiency funding to provide in-home upgrades to protect the health of building occupants. For example, almost one in four Americans are served by state-run Medicaid programs, which can be structured to provide in-home preventive services (Gottlieb and Shepard 2017). Currently, states such as Missouri, Maryland, and New York are implementing changes to state Medicaid rules that will direct some of these funds to preventive services.[3]

Funding resources can be blended together, expanding the reach of both types of intervention programs. If, for example, WAP funds can be used to fund some program services, then the cost to a partner organization of reaching patients to provide in-home preventive services can be significantly reduced. This kind of cooperation could make existing program investments even more cost effective and worthwhile.

Installing energy efficiency and safety measures are often less costly than the health problems they help to obviate. The cost of hospitalization-related medical services for a fall, for example, averages $30,000 (Burns, Stevens, and Lee 2016). Installing handrails, improved lighting, and other preventive measures will generally cost far less. That said, some health harms cost less than a typical whole-house energy efficiency retrofit. For example, an asthma-related emergency room visit costs much less than a retrofit, which can run $5,000–10,000. The whole-house approach, however, provides health benefits over multiple years, reducing asthma triggers and potentially avoiding multiple visits year after year.

EXPANDED SERVICES TO REDUCE DEFERRAL RATES

Agencies that implement WAP and utilities that offer whole-home energy efficiency programs for low-income households report high rates of deferral. These agencies and utilities often have to turn down potential participants who live in homes with structural, health, and safety issues because the providers either cannot afford to remedy them, or do not have the requisite expertise (Rose et al. 2015).[4] Conditions that can disqualify a home include mold, leaky roofs, asbestos, and other deterioration (APPRISE 2017; Wilson and

[3] These examples are discussed in Levin, Curry, and Capps 2019.

[4] During PY 2008, states and agencies were constrained to spending an average of $3,500 of DOE funds per weatherized home and were allowed to invest a small amount of money (~15%) to address health and safety issues (e.g., repairing/replacing leaky gas furnaces) (Tonn et al. 2014). The funds available to utilities to repair necessary structural and health and safety deficiencies can be even less.

Tohn 2011). This means that some of the households most in need of these services are locked out of the very programs that could help them, precisely because they need so much help. Deferrals are often caused by the very issues that would be addressed if the health measures were incorporated into an energy-saving program. By incorporating support for structural, health, and safety services into these programs, deferral rates can be reduced and more homes can be served.

The Weatherization Plus Health Initiative (Weatherization + Health) was created to help reduce deferrals for potential WAP participants (GHHI 2010). This initiative seeks to create partnerships between local providers of low-income housing repair, energy, health, and safety services to enhance collaboration and service delivery (NASCSP 2020). Washington State has initiated a Weatherization + Health program, with support from State of Washington Matchmaker funds ($1.3 million during fiscal year 2019); the state's traditional weatherization efforts are supported by state, utility, and federal funds (Washington State Department of Commerce 2020).

PARTICIPATION

Communicating the health benefits of in-home energy efficiency programs gives program administrators a powerful tool to advance change. Highlighting the health benefits of these programs can expand their appeal to a wider audience and increase participation by both market-rate and low-income households. Residents will be more likely to participate in in-home programs once they understand the various types of value that efficiency and weatherization measures bring, especially if those values are monetized (Shelton 2017).

Monetization of Health Outcomes

A 2017 ACEEE report found that a modest basket of energy efficiency investments would result in up to $20 billion per year in avoided health harms due to reduced exposure to air pollution from avoided fossil fuel use (Hayes and Kubes 2018). At that time, we noted that the health benefits we did not quantify—namely, those accruing to program participants directly due to changed conditions in their homes—might be substantially greater. Although the relationships between the built environment and health are increasingly recognized, quantifying those impacts can be challenging. Doing so will better position decision makers at utilities and in the health care sector to prioritize investments.

MONETIZING BENEFITS FOR UTILITIES

Utilities must present regulatory authorities with justifications for spending ratepayer dollars on in-home programs; they typically do this through a cost-effectiveness test that calculates program costs relative to program benefits. Despite residential energy efficiency programs' high potential for improving public health, the programs are largely administered by electric and gas utilities, and they are mandated primarily to reduce energy demand. Typically, any money spent on other goals is outside the narrow scope of approved ratepayer investments and must be approved by the utility's regulator.

Including nonenergy benefits like health in utility programs' cost-effectiveness tests is not standard practice. Although efficiency has a wide range of benefits, both energy-related and otherwise, states often disregard or undervalue many of the nonenergy benefits that accrue to utilities, program participants, and society when evaluating a program's cost

effectiveness (Russell et al. 2015; Lazar and Colburn 2013).[5] Some of the most significant omissions are health and environmental benefits, including factors such as the avoided cost of utilities' compliance with environmental regulations; improved air quality and other benefits to the environment; public health benefits due to reduced air pollution; and the improved health, safety, and welfare experienced by program participants (ACEEE 2018). ACEEE found that only nine states account for participant health benefits in cost-effectiveness tests (ACEEE 2018). Most of these states have attempted to assign a value to these benefits by developing a generic "adder" to account for health and safety benefits.

Tracking,[6] documenting, and monetizing the value of particular health outcomes is a key step in getting them included in cost-effectiveness tests. Given the limited investment funds, programs must be able to demonstrate that they will achieve health benefits in order to justify health as a priority. Once these tests include values that are tied to program performance and actual health benefits achieved, program administrators will have an incentive to build in and fund services that benefit health.

Efforts to better incorporate health into these tests are ongoing in several places. In Illinois, the IL Stakeholder Advisory Group's (SAG) Income Qualified North and IQ South Advisory Committees are working to quantify the monetary value of a set of health benefits for utility income-eligible efficiency programs for single-family and multifamily residents. These values could be incorporated into the state technical reference manual and included in cost-effectiveness tests for utility programs (Ma et al. 2018; Opinion Dynamics 2018; Income Qualified Energy Efficiency Advisory Committee 2020).

In the program territory of the Tennessee Valley Authority (TVA) territory, a study is underway to monetize the value of health benefits that result from weatherization in low-income single-family owner-occupied homes. These values will be used in a database of the program's characteristics, health impacts, and costs and savings to optimize in-home programs, particularly in moderate and hot, humid climate zones (Bruce Tonn, president, Three3, personal comm. July 2019; Three3 2020).

In Massachusetts, program evaluators are building on their prior state-based research into monetizing participant health outcomes by researching other programs and participant types. Additional research will focus on multifamily residents, the monetized benefits from reduced trip-and-fall injuries due to weatherization interventions, and health and safety

[5] Energy efficiency programs produce multiple benefits for program participants, utilities, and society as a whole. Beyond energy savings, the nonenergy benefits (NEBs) or nonenergy impacts (NEIs) from energy efficiency programs extend to health and safety improvements, job creation, environmental benefits, productivity, economic well-being, utility cost savings, water savings, and public health benefits from reduced air pollution, among others. These benefits underscore the variety of reasons that governments, utilities, businesses, homeowners, and others invest in energy efficiency upgrades. For more information on the multiple benefits that states value when determining the cost-effectiveness of utility energy efficiency programs, see NESP (2020).

[6] For more information on the methods that programs use to measure health outcomes, see Hayes and Denson 2019.

benefits in commercial and industrial buildings (Massachusetts Program Administrators 2018; Three3 and NMR Group 2018).

MONETIZING BENEFITS FOR THE HEALTH CARE SECTOR

While many millions of dollars are available for preventive care, unlocking those dollars is often contingent on the ability to demonstrate results. Once we know the dollar value of the health impacts attributable to in-home programs, we can compare the cost of a program's preventive approaches to the costs of reactively treating diseases with medications and hospital stays. These calculations can demonstrate the value proposition to hospitals, managed care organizations, public health departments, and insurers. The calculations can also make it clear that collaborative partnerships to deliver these services will generate results.[7] These quantified values thus provide a basis for both prioritizing the investment of preventive health care dollars into in-home programs and clarifying the value of pooling resources toward complementary program goals across sectors. Monetizing health benefits also incentivizes programs designed to target populations whose health will be most positively impacted: low-income households and vulnerable households burdened by chronic disease.

PREVIOUS EFFORTS TO MONETIZE HEALTH BENEFITS

In 2014, Oak Ridge National Laboratory released a report, *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program* (referred to here as the National WAP Study), which provides per-household estimates of the value of a comprehensive set of health-related benefits attributable to WAP. The report assessed and monetized 11 health- and household-related impacts attributable to income-eligible single-family homes that received weatherization services (Tonn et al. 2014). To accomplish this, researchers conducted a survey of program participants and combined those results with secondary data sources and research estimating the value of participant-reported benefits.

In 2016, program administrators from a Massachusetts income-eligible utility energy efficiency program worked with National WAP Study researchers to assess and monetize eight health outcomes experienced by the Massachusetts program's participants. The results were published in a 2016 Three3 and NMR Group report, *Low Income Single Family Health and Safety Related Non Energy Impacts Study* (here, the MA 2016 Study) (Hawkins et al. 2016). To translate the National WAP Study to a state-level analysis, the researchers modified several low-income population and medical cost data sets to reflect conditions in Massachusetts more accurately.

Then, in 2018, the state's program administrators published a report detailing preliminary results from a study that monetized 13 health outcomes experienced by participants in a multifamily residential energy efficiency program. While not yet conclusive (as the program is ongoing), the results illustrate the health outcomes that residents can experience from

[7] Monetizing impact is important, but building successful cross-sector partnerships will likely require a great deal more. For guidance on additional considerations and models for developing cross-sector partnerships, see Levin, Curry, and Capps 2019.

improved lighting and health measures and from safety measures that alleviate trip-and-fall injuries (Three3 and NMR Group 2018).

Both studies surveyed program participants and used the differences between the pre-weatherization and post-weatherization treatment groups, and between the pre-weatherization treatment and post-weatherization comparison groups, to estimate a change in health outcomes attributable to the weatherization services. Each relied on secondary data—such as state-specific or -adjusted medical incidence and cost and wage data—to quantify and monetize the health outcomes (Hawkins et al. 2016; Chan et al. 2017).[8]

Methodology of This Report

The remainder of this report aims to provide utilities, program administrators, public health advocates, health care professionals, and other decision makers with an understanding of the monetary value of in-home programs' particular health outcomes. We calculate a potential dollar value range for four health harms that could be avoided if programs were customized to target and mitigate one or more of them.

Following a discussion of our findings, Appendix A contains a variety of resources to help decision makers develop customized calculations of their own programs' avoided health harms, based on relevant local factors and program details. While not exhaustive, this list of resources can provide a starting point for compiling data related to prevalence, cost, and frequency of medical visits for a given geographic location. Decision makers can adapt the values provided within these studies and databases to meet their own needs.

We began this study by reviewing the literature on measuring health outcomes from energy efficiency and monetizing those outcomes. Many of these studies and program evaluations are detailed in Hayes and Denson (2019). We also surveyed 13 experts working at the intersection of energy efficiency and indoor health to identify key data sets, programs, and studies that could be—or have been—used to quantify and value the health benefits of energy efficiency measures.[9] To provide a range of dollar values for health outcomes attributable to energy-saving programs, we reviewed studies focused on assessing the health impacts of a bundle of complementary measures included in a typical weatherization program.

We used these findings to estimate monetized values for health benefits that might accrue from targeting four health threats:

- Asthma
- Cold-related thermal stress
- Heat-related thermal stress

[8] For the health outcomes from reduced CO poisoning and reduced home fire, the MA 2016 Study relied largely on secondary data (e.g., fire cause, CO monitor prevention, and medical cost data for fire- and CO-related injuries) to quantify values.

[9] We sent the survey to 27 subject matter experts in the fields of energy efficiency, public health, and health care, and we received 13 responses.

- Trip-and-fall injuries

These four health threats were selected based on the availability of credible data sources that we could use to develop calculations, as well as on the magnitude of the potential health impacts. Although we did not calculate the costs of these measures, the interventions selected likely represent relatively low-cost additions to a typical suite of energy efficiency measures, such as offering in-home education, removing trip hazards, and supplying handrails or special pillowcases. Many additional in-home preventive health care strategies could be folded into an energy efficiency program, including fire prevention, remediation of lead and mold, and mitigation of exposures to hazards and indoor air pollution from chemicals, carbon monoxide, and combustion sources.

For each of the four health threats selected, we created an accessible method for monetizing the outcome from in-home programs that specifically target participants most at risk for the health ailment (e.g., populations with asthma or elderly populations at risk of trip-and-fall injuries). We used data from health care and public health sources and findings from studies that monetize health outcomes from in-home interventions related to the four health threats.

For each of the four formulas, we started with an estimate of the number of homes that participate in a residential energy efficiency program each year, representing the current reach of the existing energy efficiency network nationwide. For this number, we used the estimate of 200,000.[10] We then estimated how many people living in those 200,000 homes could benefit from an in-home intervention, based on estimates of the proportion of people who would likely be at risk from each of the four health harms.[11] For thermal stress injuries, for example, we used national rates of death, hospitalization, and emergency care trips, along with estimates of the proportion of these injuries that occur from extreme temperature exposure indoors or, more specifically, in the home. In most cases, the numbers represent conservative estimates based on national averages of risk or disease incidence, whereas programs offering health services for these types of issues would likely target households in need of such services and thus reach a higher proportion of vulnerable households than the national average.

Using these estimates of the number of people who might benefit health-wise from in-home interventions to mitigate each of these four harms, we projected a potential total of avoided health harms in terms of specific health impacts (such as avoided hospital visits or deaths). Finally, we estimated the total potential monetized value of these health benefits using

[10] The leading home energy retrofit programs are Home Performance with Energy Star, a DOE program that works with state and local program operators, and WAP. In 2018, Home Performance served 86,660 homes (Dunn 2019) and WAP 33,819 homes (E. Burrin, WAP program manager, DOE, email to S. Nadel January 31, 2020). Just 52 utilities report serving over 73,000 homes annually (Relf et al. 2020). There are thousands of additional electric utilities in the United States, many offering energy efficiency programs.

[11] While our estimates are based on weatherizing 200,000 homes per year, efforts to slow climate change have included proposals to increase this number substantially. For example, a 2019 ACEEE study found that energy efficiency can be used to reduce US greenhouse emissions in half by 2050. As part of such an effort, the study examined ramping up residential retrofits to 65% of homes by 2050—an average of approximately 3 million homes per year (Nadel and Ungar 2019).

national estimates of the cost of the avoided health care or injury. We use the Environmental Protection Agency's (EPA's) accepted value of a statistical life to monetize the value of avoided mortality.

The generalized formula is as follows:

> *Dollars saved due to avoided health harm* = *Number of households reached* x *Number of vulnerable occupants* x *Number of incidents or harms avoided through intervention* x *Dollar value of avoided health harm*

Using this equation, we estimated the dollar savings that would accrue if targeted interventions for these four types of harms were incorporated into the existing network of energy efficiency programs; we then summed these values for just 1 year and after 10 years. Once a home receives an intervention, the benefits to those occupants last for multiple years, with the monetized value of benefits increasing dramatically over 10 years as the intervention's impacts continue to protect vulnerable occupants' health.

Some existing programs address these targeted health harms. For example, standard weatherization measures, such as air sealing, address some of the common asthma triggers. Also, energy-saving measures—such as air sealing and insulating the building envelope, and ensuring that heating and cooling equipment function properly—undoubtedly reduce risks of exposure to extreme thermal conditions. Our study does not attempt to determine how many programs are sufficiently addressing these health hazards now; rather, our calculations are based on an assumption that all existing programs would begin to do so.

This exercise has several other limitations. For example, we rely on national average data when available, though in some cases we base our assumptions on published results from individual programs for which national figures are not available. Further, our formulas do not distinguish findings by home type or the occupants' economic status. By taking national averages, we underestimate the impacts of, for example, asthma remediation programs targeted at low-income houses or communities of color. We therefore encourage readers to use data relevant to their regions to customize these formulas, as this may better reflect the unique circumstances of their own communities and the programs they offer.

Findings

Our estimates from the incorporation of just four health-focused interventions into the existing network of energy efficiency programs show that health benefits would be substantial: after one year, these measures could prevent more than $228 million in health harms; after 10 years, the estimated cumulative benefits of these interventions increase to $2.9 billion, assuming the same number of new participants is added to the program each year.[12] Table 1 shows these results.

[12] If 100 homes are impacted in Year 1 and 150 homes are impacted in Year 2, the cumulative benefits in Year 2 would include the dollars saved in Year 1 from 100 houses plus the dollars saved in Year 2 from 250 houses (the 150 new homes and the 100 original homes).

Table 1. Monetized health benefit potential from select in-home interventions, in 2019 dollars

	Nationwide total after one year	Nationwide total after 10 years
Reduced trip-and-fall injuries	$177,200,000	$2,180,000,000
Reduced asthma symptoms	$38,500,000	$593,000,000
Reduced heat-related thermal stress	$8,000,000	$73,000,000
Reduced cold-related thermal stress	$4,600,000	$41,000,000
Total monetized health benefits from four targeted interventions	$228,000,000	$2,888,000,000

These numbers are a fraction of what is possible, as they represent only a few selected benefits from the long list of health outcomes that might accrue to households participating in an in-home energy efficiency program. The following are among the many potentially achievable benefits:

- Reduced exposure to mold, humidity, and excess moisture
- Reduced cockroach, rodent, and other pest infestations
- Improved indoor air quality and reduced exposure to outdoor air pollution
- Reduced home fires
- Improved sleep
- Fewer missed days at work and school
- Reduced "heat, treat, or eat" choice dilemma and improved ability to afford prescription medications
- Improved comfort of the home
- Reduced stress from lower living expenses and improved living conditions

We describe the calculations and resources for this analysis in greater detail below; we include these resources both for transparency and to encourage customized calculations that reflect a reader's specific program offerings and community conditions.

For each of the four targeted health outcomes, we first define the health threat and its prevalence in the United States and describe how in-home services can affect the health outcome. We then apply the formula described above to each health threat.

REDUCED ASTHMA SYMPTOMS

Asthma is a chronic disease affecting the airways inside the lungs; during an asthma attack, it can be hard to breath and attacks are sometimes fatal. In the United States, 1 out of every 12 people suffers from asthma, and the disease disproportionately impacts communities of color (CDC 2019a, 2019c). Children experience asthma at a higher rate than adults, and the prevalence of Black children experiencing asthma is nearly twice that of White children

(CDC 2019c).[13] People with asthma are also at increased risk of developing chronic obstructive pulmonary disease (COPD) (Salvi and Barnes 2009), which is associated with higher health care utilization and treatment costs (Vermont Department of Health 2018). It is estimated that asthma costs Americans a total of nearly $82 billion per year (Nurmagambetov, Kuwahara, and Garbe 2018).

Homes may contain a number of asthma triggers, including mold, dust mites, and pests (CDC 2010). Additional factors that can trigger asthma attacks include extreme indoor temperatures, humidity and moisture, and other sources of poor air quality (Vermont Department of Health 2018). Leaky windows and poor insulation, for example, can lead to cold drafts and extreme temperatures in a home, which can in turn trigger asthma attacks and exacerbate other respiratory illnesses (AAFA 2020; American Lung Association 2018). Poorly sealed building envelopes also make it easier for pests and moisture to infiltrate, which can lead to mold growth and the introduction of allergens and disease.

Changes to a living environment can help to limit emergency department visits, hospitalizations, and other medical costs associated with asthma by reducing triggers within the home that can cause an attack (Breysse et al. 2011; Breysse et al. 2014; Osman et al. 2010; Rose et al. 2015). Implementing energy efficiency measures can mitigate all of these risks and make homes healthier by sealing up building envelopes, improving ventilation, increasing insulation, and repairing or upgrading heating and cooling equipment (Francisco et al. 2016; Leech, Raizenne, and Gusdorf 2004; Wallner et al. 2015; Wilson et al. 2014). Offering health and safety measures—such as mold remediation, and providing pillow covers and low-emission vacuums—alongside these energy efficiency measures through in-home programs can help to alleviate asthma triggers (Breysse, et al. 2014; Rose et al. 2015).

Table 2 presents a simplified calculation of the potential cost savings achievable through avoided health harms if in-home programs were customized to target participants with asthma. We report estimates for 1 year of cost savings nationwide, as well as savings that would accrue over 10 years by adding the same number of new participants to the program annually.

[13] In 2017, asthma prevalence nationwide for White children was 7.7% compared to 12.6% and 11.3% for Black and Puerto Rican children, respectively.

Table 2. Monetary value of reduced asthma hospitalizations, ER visits, and deaths, in 2019 dollars

Category	Calculation	Result
Number of people reached	Houses served[1] x People per household[2]	200,000 x 2.6
Number of vulnerable occupants	Percentage of the population with asthma[3]	8.3%
Number of incidences avoided through intervention	Rate of hospitalization[4]/ER visits[5]/deaths per patients[6]	0.8%/7%/0.001%
	Percentage of hospital visits[7]/ER visits[8]/deaths avoided through intervention[9]	65.5%/27.7%/65.5%
Dollar value of avoided health harm	Cost of an ER visit[10]	$1,784
	Cost of a hospitalization[11]	$25,497
	Value of a life[12]	$9,400,000
Total savings in one year = $38,500,000		
Cumulative savings over 10 years[13] = $593,100,000		

[1] ACEEE estimate. [2] Census Bureau 2017. [3] CDC 2019c. [4] AAFA 2019. [5] CDC 2019a. [6] CDC 2019a. [7] Norton and Brown 2014. [8] Ibid. [9] Ibid. (hospital visits avoided used as proxy). [10] Wang et al. 2014. [11] HCUP 2016. [12] EPA 2018. [13] Discount rate of 3% applied.

REDUCED TRIP-AND-FALL INJURIES

Each year, 30 million older adults fall, resulting in about 30,000 deaths (Bergen, Stevens, and Burns 2016) and 3 million visits to emergency departments for injury treatment (CDC 2019d). Such falls can result in serious injuries, including broken bones and head injuries, as well as weakness that can lead to greater risk of future falls (CDC 2017). Falls can impact quality of life, particularly for older adults whose fear of falling can lead to limiting activities, physical decline, depression, and social isolation (NCOA 2018). The medical costs associated with trips and falls in adults over 65 were estimated at more than $50 billion nationally in 2015 (CDC 2017).

To prevent trips and falls in the home, the CDC recommends installing good lighting, stair handrails, and shower grab bars (CDC 2015). Additional modifications might include installing ramps; repairing steps; installing raised, water-conserving toilets; and making modifications to reduce other trip hazards (Tohn et al. 2020). Studies have shown that in-home interventions such as these can reduce trips and falls that require older adults to seek medical attention (Breysse et al. 2015; Tohn et al. 2020; Moylan and Binder 2007).

Table 3 summarizes potential cost savings from avoided health harms that could be achieved if programs were customized to target participants at risk for trip-and-fall injuries.

Table 3. Monetary value of avoided trip-and-fall hospital visits and deaths, in 2019 dollars

Category	Calculation	Result
Number of people reached	Houses served[1] x People per household[2]	200,000 x 2.6
Number of vulnerable occupants	Percentage of the population aged 65 and older[3] x Percentage of older adults that fall annually[4]	16% x 25%
Number of incidences avoided through intervention	Percentage of falls that result in death[5]/hospitalization[6]	0.1%/2.8%
	x Percentage of falls avoided through intervention[7]	77%
Dollar value of avoided health harm	Costs related to a hospitalization[8]	$32,918
	Value of a life saved[9]	$9,400,000
Total savings in one year = $177,200,000		
Cumulative savings over 10 years[10] = $2,180,000,000		

[1] ACEEE estimate. [2] Census Bureau 2017. [3] CDC 2015. [4] CDC 2017. [5] Ibid. [6] Ibid. [7] Tonn et al. 2020. [8] Burns, Stevens, and Lee 2016. [9] EPA 2018. [10] Discount rate of 3% applied.

REDUCED COLD-RELATED THERMAL STRESS

Extreme indoor thermal conditions—temperatures and drafts—can have significant adverse health effects. When people experience prolonged exposures to very cold temperatures, they can develop hypothermia; infants and elderly populations are especially at risk (CDC 2019b). Hypothermia can affect the brain, causing confusion and drowsiness, as well as lead to heart and respiratory system failure and even death. According to a data review by the Healthcare Cost and Utilization Project (Merrill, Miller, and Steiner 2008), in 2005 alone there were more than 12,000 US hospitalizations related to excessive heat or cold, with a combined national cost of more than $120 million.

Weatherization measures in cold climates address inadequate heating systems and excessive drafts in homes, decreasing the chances of households experiencing dangerously cold temperatures (Tonn et al. 2014). Weatherization programs can target populations that are particularly at risk for developing cold-related thermal stress, including households with inadequate food, clothing, or heating systems; children and/or elderly occupants; and individuals with chronic medical conditions (Mayo Clinic 2019). By air-sealing building envelopes and installing insulation, weatherization efforts can reduce heat loss and mitigate thermal stress for building occupants (Norton, Brown, and Malomo-Paris 2017).

Table 4 calculates potential cost savings that could be achieved through avoided health harms if programs were customized to target participants who are at risk for cold-related thermal stress.

Table 4. Monetary value of avoided cold-related thermal stress hospitalizations, ER visits, and deaths, in 2019 dollars

Category	Calculation	Result
Number of people reached	Houses served[1] x People per household[2]	200,000 x 2.6
Number of vulnerable occupants	Annual rate of hypothermia incidents nationwide[3]	Emergency room (ER) visits: 17,129 Hospitalizations: 7,170 Deaths: 1,330 / US population: 329,978,232
Number of incidences avoided through intervention	Percentage of harms avoided by intervention[4]	23%
Dollar value of avoided health harm	Cost of an ER visit[5] Cost of a hospitalization[6] Value of a life saved[7]	$558 $10,072 $9,400,000
Total savings in one year = $4,600,000		
Cumulative savings over 10 years[8] = $41,000,000		

[1] ACEEE estimate. [2] Census Bureau 2017. [3] CDC 2019b; HCUP 2018. [4] Extrapolated from CDC 2006. [5] HCUP 2018. [6] Ibid. [7] EPA 2018. [8] Discount rate of 3% applied.

REDUCED HEAT-RELATED THERMAL STRESS

High temperatures and humidity can have significant adverse health effects. Heat-related illness (or *hyperthermia*) results when people are exposed to extreme heat and cannot properly cool, causing their body temperature to rapidly rise. High humidity can inhibit the body's ability to evaporate sweat quickly, preventing the body from releasing heat rapidly enough (CDC 2016a). Exposure to excessive heat inside the home can lead to heat exhaustion or heat stroke, which can cause fatigue, headache, nausea, fainting, muscle cramping, confusion, and rapid pulse (CDC 2016a).

Weatherization addresses inadequate cooling systems and improves home ventilation, decreasing the chances of households experiencing dangerously hot temperatures that can lead to heat-related illnesses (Tonn et al. 2014). Weatherization programs can target households with inadequate cooling systems, children and/or elderly occupants, and individuals with chronic medical conditions (CDC 2016a).

Table 5 calculates potential cost savings that could be achieved through avoided health harms if the existing network of programs were customized to target participants at risk for heat-related thermal stress.

Table 5. Monetary value of avoided heat-related thermal stress hospitalizations, ER visits, and deaths, in 2019 dollars

Category	Calculation	Result
Number of people reached	Houses served[1] x People per household[2]	200,000 x 2.6
Number of vulnerable occupants	Annual rate of hyperthermia incidents nationwide[3]	Emergency room (ER) visits: 61,725 Hospitalizations: 3,860 Deaths: 668 / US population: 329,978,232
Number of incidences avoided through intervention	Percentage of harms avoided by intervention[4]	80%
Dollar value of avoided health harm	Cost of an ER visit[5] Cost of a hospitalization[6] Value of a life saved[7]	$665 $6,180 $9,400,000
Total savings in one year = $8,000,000		
Cumulative savings over 10 years[8] = $73,000,000		

[1] ACEEE estimate. [2] Census Bureau 2017. [3] CDC 2016a; HCUP 2018. [4] NYC DHMH 2020. [5] HCUP 2018. [6] Ibid. [7] EPA 2018.
[8] Discount rate of 3% applied.

Conclusion

As the national health care system shifts toward a holistic view of health, the recognition that illness and wellness play out within an influential system of social determinants has enormous potential to reshape the funding conversation around the appropriate and efficient use of scarce resources to protect health. The existing network of energy-saving programs touches households nationwide, and it is well suited to deliver in-home preventive services. As a greater diversity of preventive health care methods are examined and their health benefits measured and quantified, programs encompassing these methods will be better positioned to become a resource for public health. Quantifying health benefits lets administrators of both energy-saving programs and preventive health programs explore potential partnerships to more effectively—and cost effectively—bring health benefits to the households they serve. Our estimates of potential health benefits offer a method that individual programs can employ using their own detailed local data. Further research on these impacts would be useful, both to refine these types of estimates and to identify other threats to public health that can be tackled with in-home weatherization networks.

References

AAFA (Asthma and Allergy Foundation of America). 2020. "Weather Can Trigger Asthma." www.aafa.org/page/weather-triggers-asthma.aspx.

American Council for an Energy-Efficient Economy (ACEEE) 2018. *Cost-Effectiveness Tests: Overview of State Approaches to Account for Health and Environmental Benefits of Energy Efficiency*. Washington, DC: ACEEE. www.aceee.org/topic-brief/he-in-ce-testing.

——. 2019. "Guidelines for Low-Income Energy Efficiency Programs." database.aceee.org/state/guidelines-low-income-programs.

Akinbami, L., J. Moorman, C. Bailey, H. Zahran, M. King, C. Johnson, and X. Liu. 2012. *Trends in Asthma Prevalence, Health Care Use, and Mortality in the United States, 2001–2010*. Hyattsville, MD: National Center for Health Statistics. www.cdc.gov/nchs/data/databriefs/db94.pdf.

American Lung Association. 2018. "Cold Weather and Your Lungs." www.lung.org/about-us/media/top-stories/cold-weather-your-lungs.html.

APPRISE (Applied Public Policy Research Institute for Study and Evaluation). 2017. *Low-Income Energy Efficiency Opportunities Study*. New York: EDF (Environmental Defense Fund). www.edf.org/sites/default/files/APPRISE_Low-Income-Energy-Efficiency-Opportunities-Study-2017.PDF.

ATSDR (Agency for Toxic Substances and Disease Registry). 2020. "Asbestos and Your Health." Accessed February. atsdr.cdc.gov/asbestos/.

Berg, W., S. Vaidyanathan, E. Junga, E. Cooper, C. Perry, G. Relf, A. Whitlock, M. DiMascio, C. Waters, and N. Cortez. 2019. *2019 State Energy Efficiency Scorecard*. Washington, DC: ACEEE. www.aceee.org/research-report/u1908.

Bergen, G., M. Stevens, and E. Burns. 2016. "Falls and Fall Injuries among Adults Aged ≥ 65 Years—United States, 2014. *Morbidity and Mortality Weekly Report* 65 (37): 993–8. www.cdc.gov/mmwr/volumes/65/wr/mm6537a2.htm.

Breysse, J., D. Jacobs, W. Weber, S. Dixon, C. Kawecki, S. Aceti, and J. Lopez. 2011. "Health Outcomes and Green Renovation of Affordable Housing." *Public Health Reports* 126 (Supplement l): 64–75. www.ncbi.nlm.nih.gov/pmc/articles/PMC3072905.

Breysse, J., S. Dixon, J. Gregory, M. Philby, D. Jacobs, and J. Krieger. 2014. "Effect of Weatherization Combined with Community Health Worker In-Home Education on Asthma Control." *American Journal of Public Health* 104 (1): e57–64. www.ncbi.nlm.nih.gov/pmc/articles/PMC3910032/.

Breysse, J., S. Dixon, D. Jacobs, J. Lopez, and W. Weber. 2015. "Self-Reported Health Outcomes Associated with Green-Renovated Public Housing among Primarily Elderly Residents." *Journal of Public Health Management and Practice* 21 (4): 335–67. www.ncbi.nlm.nih.gov/pubmed/25679773.

Brown, A. 2012. "With Poverty Comes Depression, More than Other Illnesses." *Gallup News*, October 30. news.gallup.com/poll/158417/poverty-comes-depression-illness.aspx.

Burns, E., J. Stevens, and R. Lee. 2016. "The Direct Costs of Fatal and Non-Fatal Falls among Older Adults—United States." *Journal of Safety Research* 58 (September): 99–103. www.sciencedirect.com/science/article/pii/S0022437516300172?via%3Dihub.

CCIOO (Center for Consumer Information and Insurance Oversight). 2010. "Background: The Affordable Care Act's New Rules on Preventive Care." www.cms.gov/CCIIO/Resources/Fact-Sheets-and-FAQs/preventive-care-background.

CDC (Centers for Disease Control and Prevention). 2006. "Morbidity and Mortality Weekly Report: Hypothermia-Related Deaths—United States, 1999–2002 and 2005." *Morbidity and Mortality Weekly Report* 55 (10): 282–4. www.cdc.gov/mmwr/preview/mmwrhtml/mm5510a5.htm.

———. 2010. "Common Asthma Triggers." www.cdc.gov/asthma/triggers.html.

———. 2015. *Check for Safety: A Home Fall Prevention Checklist for Older Adults*. Atlanta: CDC. www.cdc.gov/steadi/pdf/check_for_safety_brochure-a.pdf.

———. 2016a. *Picture of America: Heat-Related Illness*. Atlanta: CDC. www.cdc.gov/pictureofamerica/pdfs/picture_of_america_heat-related_illness.pdf.

———. 2017. "Important Facts about Falls." www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html.

———. 2018. "Social Determinants of Health (SDOH)." www.cdc.gov/socialdeterminants/index.htm.

———. 2019a. "Asthma." www.cdc.gov/asthma/default.htm.

———. 2019b. "Hypothermia." www.cdc.gov/disasters/winter/staysafe/hypothermia.html.

———. 2019c. "Most Recent Asthma Data." www.cdc.gov/asthma/most_recent_data.htm.

———. 2019d. "Welcome to WISQARS™." www.cdc.gov/injury/wisqars/.

Census Bureau. 2017. "American Housing Survey (AHS) Table Creator." www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html#?s_areas=a00000&s_year=n2017&s_tableName=Table1&s_byGroup1=a1&s_byGroup2=a1&s_filterGroup1=t1&s_filterGroup2=g1&s_show=S.

Chan, C., G. Clendenning, B. Hawkins, E. Rose, and B. Tonn. 2017. "Saving Lives through Energy Efficiency: Valuing the Health- and Safety-Related Benefits of Weatherization in Low-Income Homes." In *Proceedings of the 2017 International Energy Program Evaluation Conference*. Madison, WI: IEPEC (International Energy Program Evaluation Conference). www.nmrgroupinc.com/wp-content/uploads/2019/01/Gregs-paper.pdf.

Cluett, R., J. Amann, and S. Ou. 2016. *Building Better Energy Efficiency Programs for Low-Income Households*. Washington, DC: ACEEE. www.aceee.org/sites/default/files/publications/researchreports/a1601.pdf.

DOE (Department of Energy). 2019. *Weatherization Works!* Washington, DC: DOE. www.energy.gov/sites/prod/files/2019/07/f64/WAP-Fact-Sheet-2019.pdf.

——. 2020. "About the Weatherization Assistance Program." Accessed February. www.energy.gov/eere/wipo/about-weatherization-assistance-program-0.

Drehobl, A., and L. Ross. 2016. *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*. Washington, DC: ACEEE. aceee.org/research-report/u1602.

Dunn, S. 2019. "Home Performance with ENERGY STAR." PowerPoint presentation to Residential Buildings Integration Peer Review—Partnership Session. April 19. Buildings Technology Office, DOE.

EPA (Environmental Protection Agency). 2018. "Mortality Risk Evaluation." www.epa.gov/environmental-economics/mortality-risk-valuation.

——. 2019. "Protect Your Family from Exposures to Lead." epa.gov/lead/protect-your-family-exposures-lead.

Francisco, P., D. Jacobs, L. Targos, S. Dixon, J. Breysse, W. Rose, and S. Cali. 2016. "Ventilation, Indoor Air Quality, and Health in Homes Undergoing Weatherization." *Indoor Air* 27 (2): 463–77. www.ncbi.nlm.nih.gov/pubmed/27490066.

GHHI (Green & Healthy Homes Initiative). 2010. *Identified Barriers and Opportunities to Make Housing Green and Healthy through Weatherization: A Report from Green and Healthy Homes Initiative Sites*. Prepared by the National Coalition to End Childhood Lead Poisoning. Baltimore: GHHI. www.greenandhealthyhomes.org/wp-content/uploads/GHHI-Weatherization-Health-and-Safety-Report1.pdf.

Gilleo, A., S. Nowak, and A. Drehobl. 2017. *Making a Difference: Strategies for Successful Low-Income Energy Efficiency Programs*. Washington, DC: ACEEE. www.aceee.org/research-report/u1713.

Go, A., D. Mozaffarian, V. Roger, E. Benjamin, J. Berry, W. Borden, D. Bravata, S. Dai, E. Ford, C. Fox, S. Franco, H. Fullerton, C. Gillespie, S. Hailpern, J. Heit, V. Howard, M. Huffman, B. Kissela, S. Kittner, D. Lackland, J. Lichtman, L. Lisabeth, D. Magid, G. Marcus, A. Marelli, D. Matchar, D. McGuire, E. Mohler, C. Moy, M. Mussolino, G. Nichol, N. Paynter, P. Schreiner, P. Sorlie, J. Stein, T. Turan, S. Virani, N. Wong, D. Woo, and M. Turner. 2013. "Heart Disease and Stroke Statistics—2013 Update: A Report from the American Heart Association." *Circulation* 127 (1): e6–245. www.ahajournals.org/doi/abs/10.1161/cir.0b013e31828124ad.

Gottlieb J., and M. Shepard. 2017. "Evidence of the Value of Medicaid." *EconoFact*, July 2. econofact.org/evidence-on-the-value-of-medicaid.

Hawkins, B., B. Tonn, E. Rose, G. Clendenning, and L. Abraham. 2016. *Massachusetts Special and Cross-Cutting Research Area: Low-Income Single-Family Health- and Safety-Related Non-Energy Impacts (NEIs) Study*. Boston: Massachusetts Program Administrators. ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Single-Family-Health-and-Safety-Related-Non-Energy-Impacts-Study.pdf.

Hayes, S., and C. Kubes. 2018. *Saving Energy, Saving Lives: The Health Impacts of Avoiding Power Plant Pollution with Energy Efficiency*. Washington, DC: ACEEE. aceee.org/research-report/h1801.

Hayes, S., and R. Denson. 2019. *Protecting the Health of Vulnerable Populations with In-Home Energy Efficiency: A Survey of Methods for Demonstrating Health Outcomes*. Washington, DC: ACEEE. www.aceee.org/research-report/h1901.

HCUP (Healthcare Cost and Utilization Project). 2018. "Introduction to the HCUP National Inpatient Sample 2016." hcup-us.ahrq.gov/db/nation/nis/NIS_Introduction_2016.jsp.

Hernández, D. 2016. "Understanding 'Energy Insecurity' and Why It Matters to Health." *Social Science & Medicine* 167: 1–10. www.ncbi.nlm.nih.gov/pmc/articles/PMC5114037/.

Income Qualified Energy Efficiency Advisory Committee. 2020. "Income Qualified EE Advisory Committee." iqadvisorycommittee.com/.

Lazar, J., and K. Colburn. 2013. *Recognizing the Full Value of Energy Efficiency (What's under the Feel-Good Frosting of the World's Most Valuable Layer Cake of Benefits)*. Montpelier, VT: RAP (Regulatory Assistance Project). www.raponline.org/wp-content/uploads/2016/05/rap-lazarcolburn-layercakepaper-2013-sept-09.pdf.

Leech, J., M. Raizenne, and J. Gusdorf. 2004. "Health in Occupants of Energy Efficient New Homes." *Indoor Air* 14 (3): 169–73. www.ncbi.nlm.nih.gov/pubmed/15104783.

Levin, E., L. Curry, and L. Capps. 2019. *Energy-Plus-Health Playbook*. Burlington, VT: VEIC. www.veic.org/resource-library/energy-plus-health-playbook.

Ma, J., P. Plympton, J. Minor-Baetens, C. Lamar, and K. Johnson. 2018. *Quantifying Non-Energy Benefits from ComEd's Income Eligible Programs: Findings and Recommendations from Secondary Research*. Prepared by Navigant Consulting, Inc. Oak Brook, IL: Commonwealth Edison. s3.amazonaws.com/ilsag/ComEd_Income_Eligible_Programs_NEBs_Secondary_Research_Report_2018-03-06.pdf.

Massachusetts Program Administrators. 2018. *Non-Energy Impact Framework Study Report*. Prepared by Tetra Tech, Inc. Boston: Massachusetts Program Administrators. ma-eeac.org/wordpress/wp-content/uploads/NEI-Framework-Study-Report.pdf.

Mayo Clinic. 2019. "Hypothermia." www.mayoclinic.org/diseases-conditions/hypothermia/symptoms-causes/syc-20352682.

Merrill, C., M. Miller, and C. Steiner. 2008. *Hospital Stays Resulting from Excessive Heat and Cold Exposure Due to Weather Conditions in US Community Hospitals, 2005*. HCUP (Healthcare Cost and Utilization Project) Statistical Brief #55. Rockville, MD: Agency for Healthcare Research and Quality. hcup-us.ahrq.gov/reports/statbriefs/sb55.jsp.

Moylan, D., and E. Binder. 2007. "Falls in Older Adults: Risk Assessment, Management and Prevention." *American Journal of Medicine* 120 (6): 493–7. www.amjmed.com/article/S0002-9343(06)00903-X/fulltext.

Nadel, S., and L. Ungar. 2019. *Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050*. Washington, DC: ACEEE. aceee.org/sites/default/files/publications/researchreports/u1907.pdf.

NASCSP (National Association for State Community Services Programs). 2020. "Weatherization Plus Health." Accessed February. nascsp.org/wap/waptac/wap-resources/weatherization-plus-health/.

NCHH (National Center for Healthy Housing). 2020. "Weatherization Plus Health." nchh.org/information-and-evidence/healthy-housing-policy/national/keystone-federal-policy/wx-plus-health/.

NCOA (National Council on Aging). 2018. *Falls Prevention Awareness Day: 2017 Impact Report*. Arlington, VA: NCOA. d2mkcg26uvg1cz.cloudfront.net/wp-content/uploads/2017-FPAD-Compendium-1.pdf.

NESP (National Efficiency Screening Project). 2020. "Database of State Efficiency Screening Practices (DSESP)." nationalefficiencyscreening.org/state-database-dsesp/.

Norton, R., and B. Brown. 2014. "Green & Healthy Homes Initiative: Improving Health, Economic, and Social Outcomes Through Integrated Housing Intervention." *Environmental Justice* 7 (6): 151-157. doi.org/10.1089/env.2014.0033.

Norton, R., B. Brown, and K. Malomo-Paris. 2017. *Weatherization and Its Impact on Occupant Health Outcomes*. Baltimore: GHHI (Green & Healthy Homes Initiative). www.greenandhealthyhomes.org/wp-content/uploads/Weatherization-and-its-Impact-on-Occupant-Health_Final_5_23_2017_online.pdf.

Nurmagambetov, T., R. Kuwahara, and P. Garbe. 2018. "The Economic Burden of Asthma in the United States, 2008–2013." *Annals of the American Thoracic Society* 15 (3): 348–56. www.atsjournals.org/doi/10.1513/AnnalsATS.201703-259OC.

NYC DHMH (New York City Department of Health and Mental Hygiene). 2020. "Extreme Heat and Your Health." www1.nyc.gov/site/doh/health/emergency-preparedness/emergencies-extreme-weather-heat.page.

Oates, G., B. Jackson, E. Partridge, K. Singh, M. Fouad, and S. Bae. 2017. "Sociodemographic Patterns of Chronic Disease: How the Mid-South Region Compares to the Rest of the Country." *American Journal of Preventive Medicine* 52 (1, Supplement 1): S31–9. www.ncbi.nlm.nih.gov/pmc/articles/PMC5171223/.

Opinion Dynamics. 2018. *Non-Energy Impact Literature Review for Ameren Illinois Company*. Chicago: Ameren Illinois. s3.amazonaws.com/ilsag/REPORT_AIC_NEI_Literature_Review_Findings_Final_2018-11-19.pdf.

Osman, L., J. Ayres, C. Garden, K. Reglitz, J. Lyon, and J. Douglas. 2010. "A Randomised Trial of Home Energy Efficiency Improvement in the Homes of Elderly COPD Patients." *European Respiratory Journal* 35 (2): 303–9. www.ncbi.nlm.nih.gov/pubmed/19643937.

Relf, G., E. Cooper, R. Gold, A. Goyal, and C. Waters. 2020. *2020 Utility Energy Efficiency Scorecard*. Washington, DC: ACEEE. www.aceee.org/research-report/u2004.

Rose, E., B. Hawkins, L. Ashcraft, and C. Miller. 2015. *Exploratory Review of Grantee, Subgrantee and Client Experiences with Deferred Services under the Weatherization Assistance Program*. Prepared by ORNL (Oak Ridge National Laboratory). Washington, DC: DOE. weatherization.ornl.gov/wp-content/uploads/pdf/WAPRecoveryActEvalFinalReports/ORNL_TM-2014_364.pdf.

Russell, C., B. Baatz, R. Cluett, and J. Amann. 2015. *Recognizing the Value of Energy Efficiency's Multiple Benefits*. Washington, DC: ACEEE. www.aceee.org/sites/default/files/publications/researchreports/ie1502.pdf.

Salvi, S., and P. Barnes. 2009. "Chronic Obstructive Pulmonary Disease in Non-Smokers." *Lancet* 374 (9691): 733–43. www.ncbi.nlm.nih.gov/pubmed/19716966.

Shelton, S. 2017. "Creating a Social Norm around Energy Efficiency." In *Proceedings of the 2017 ACEEE/CEE Symposium on Market Transformation*. Washington, DC: ACEEE. www.aceee.org/sites/default/files/pdf/conferences/mt/2017/Shelton_Keynote_MT17_4.3.17.pdf.

Three³. 2020. "Current Projects." www.threecubed.org/current-projects.html.

Three³ and NMR Group. 2018. *Low-Income Multifamily Health- and Safety-Related NEIs Study (TXC 50) Preliminary Findings Report*. Boston: Massachusetts Program Administrators. ma-eeac.org/wordpress/wp-content/uploads/TXC50-Low-Income-Multfamily-Health-and-Safety-NEI-Preliminary-Findings-Report_15OCT2018.pdf.

Tohn, E., J. Wilson, T. Van Oss, and M. Gurecka. 2020. "Incorporating Injury Prevention into Energy Weatherization Programs." *Journal of Public Health Management and Practice* 26 (1): 80–2. journals.lww.com/jphmp/Citation/2020/01000/Incorporating_Injury_Prevention_Into_Energy.14.

Tonn B., E. Rose, B. Hawkins, and B. Conlon. 2014. *Health and Household-Related Benefits Attributable to the Weatherization Assistance Program.* Prepared by ORNL (Oak Ridge National Laboratory). Washington, DC: DOE. weatherization.ornl.gov/wp-content/uploads/pdf/WAPRetroEvalFinalReports/ORNL_TM-2014_345.pdf.

Vermont Department of Health. 2018. *Weatherization + Health: Health and Climate Change Co-Benefits of Home Weatherization in Vermont*. Burlington: Vermont Department of Health. www.healthvermont.gov/sites/default/files/documents/pdf/ENV_CH_WxHealthReport.pdf.

Wallner, P., U. Munoz, P. Tappler, A. Wanka, M. Kundi, J. Shelton, and H. Hutter. 2015. "Indoor Environmental Quality in Mechanically Ventilated, Energy-Efficient Buildings vs. Conventional Buildings." *International Journal of Environmental Research and Public Health* 12 (11): 14132–47. www.ncbi.nlm.nih.gov/pubmed/26561823.

Wang, T., T. Srebotnjak, J. Brownell, and R. Hsia. 2014. "Emergency Department Charges for Asthma-Related Outpatient Visits by Insurance Status." *Journal of Health Care for the Poor and Underserved* 25 (1): 396–405. muse.jhu.edu/article/536594.

Washington State Department of Commerce. 2020. "Weatherization Plus Health." www.commerce.wa.gov/growing-the-economy/energy/weatherization-and-energy-efficiency/matchmaker/weatherization-plus-health-wxh/.

Wilson, J., and E. Tohn. 2011. *Healthy Housing Opportunities during Weatherization Work*. Prepared by NREL (National Renewable Energy Laboratory). Washington, DC: DOE. www.nrel.gov/docs/fy11osti/49947.pdf.

Wilson, J., S. Dixon, D. Jacobs, J. Breysse, J. Akoto, E. Tohn, M. Isaacson, A. Evens, and Y. Hernandez. 2014. "Watts-to-Wellbeing: Does Residential Energy Conservation Improve Health?" *Energy Efficiency* 7 (1): 151–60. doi.org/10.1007/s12053-013-9216-8.

Zhao, N. 2017. "The Aging Housing Stock." *Eye on Housing*, January 5. eyeonhousing.org/2017/01/the-aging-housing-stock-3/.

Appendix A. Resources for Customized Calculations

Table A1. Resources related to monetizing reduced asthma symptoms for building occupants

Area of focus	Level of geographic specification	Resource
Prevalence of health impact		
Asthma prevalence % for children	National	CDC www.cdc.gov/mmwr/volumes/67/wr/mm6705e1.htm
Asthma prevalence % for children and adults	National	AAAAI www.aaaai.org/about-aaaai/newsroom/asthma-statistics
Reduction in juvenile asthma through housing quality intervention	City	GHHI doi.org/10.1089/env.2014.0033
Hospital and emergency room visits		
Frequency of hospital admittance for asthma (adults and children)		AAAAI www.aaaai.org/about-aaaai/newsroom/asthma-statistics
Frequency of hospital re-admittance for asthma by state	State	HCUP www.hcup-us.ahrq.gov/reports/statbriefs/sb90.jsp
Frequency of hospital re-admittance for asthma	National	NCBI www.ncbi.nlm.nih.gov/pmc/articles/PMC4950546/
Medical costs		
Average Emergency Department visit costs	National	NCBI www.ncbi.nlm.nih.gov/pmc/articles/PMC4063557/
Medical cost data for insured and uninsured by zip/city and state	State, city, and zip code	Costlookup. Welcome to FAIR Health www.fairhealthconsumer.org/
Average expense for asthma treatment per person	National	MEPS meps.ahrq.gov/data_files/publications/st487/stat487.pdf
Statistics and mortality		
Value of a statistical life	National	RFF www.rff.org/publications/all-publications/?topic=1554
Mortality risk valuation	National	EPA www.epa.gov/environmental-economics/mortality-risk-valuation

Table A2. Resources related to monetizing reduced cold-related thermal stress for building occupants

Area of focus	Level of geographic specification	Resource
Prevalence of health issue		
Low-income residents with inadequate housing	National	NCHH nchh.org/resources/policy/substandard-housing/
Burden and risk factors for cold-related illness and death in New York City	City	International Journal of Environmental Research and Health www.ncbi.nlm.nih.gov/pmc/articles/PMC5923674/
Hospital and emergency room visits		
Hospitalizations, ED visits, and physician office visits related to cold	State	Department of Health and Human Services (HHS) sponsored by the Agency for Healthcare Research and Quality (AHRQ) - Medical Expenditure Panel Survey (MEPS) meps.ahrq.gov/mepsweb/
Hospital stays resulting from temperature extremes due to weather conditions in US community hospitals, 2005	National	Healthcare Cost and Utilization Project (HCUP) www.hcup-us.ahrq.gov/reports/statbriefs/sb55.pdf www.ncbi.nlm.nih.gov/books/NBK56045/
Medical costs		
Average cost for hospitalizations, ED visits	State	HHS AHRQ - Medical Expenditure Panel Survey (MEPS) meps.ahrq.gov/mepsweb/
Average cost for physician office visits (Medicare, Medicaid, private insurance, uninsured)	State	Healthcare Cost and Utilization Project (HCUP) www.ahrq.gov/research/index.html
Statistics and mortality		
Number of deaths due to extreme cold	National	National Health Statistics Reports www.cdc.gov/nchs/data/nhsr/nhsr076.pdf
Value of a statistical life		RFF www.rff.org/publications/all-publications/?topic=1554
Mortality risk valuation		EPA www.epa.gov/environmental-economics/mortality-risk-valuation

Table A3. Resources related to monetizing reduced heat-related thermal stress for building occupants

Area of focus	Level of geographic specification	Resource
Prevalence of health issue		
Low-income residents with inadequate housing	National	NCHH nchh.org/resources/policy/substandard-housing/
Heat-related hospitalizations for elderly	National	NCBI www.ncbi.nlm.nih.gov/pmc/articles/PMC5225426/
Hospital and emergency room visits		
Hospitalizations, ED visits, and physician office visits	State	Department of Health and Human Services (DHHS) sponsored by the Agency for Healthcare Research and Quality (AHRQ) - Medical Expenditure Panel Survey (MEPS) meps.ahrq.gov/mepsweb/
Medical costs		
Average cost for hospitalizations, ED visits	State	DHHS AHRQ - Medical Expenditure Panel Survey (MEPS) meps.ahrq.gov/mepsweb/ Healthcare Cost and Utilization Project hcupnet.ahrq.gov/#setup
Average cost for physician office visits (Medicare, Medicaid, private insurance, uninsured)	State	Healthcare Cost and Utilization Project (HCUP) www.ahrq.gov/research/index.html
Statistics and mortality		
Deaths due to extreme heat	National	CDC www.cdc.gov/pictureofamerica/pdfs/picture_of_america_heat-related_illness.pdf
Value of a statistical life	National	RFF www.rff.org/publications/all-publications/?topic=1554
Mortality risk valuation	National	EPA www.epa.gov/environmental-economics/mortality-risk-valuation

Table A4. Resources related to monetizing avoided trip-and-fall injuries for building occupants

Area of focus	Level of geographic specification	Resource
Prevalence of health issue		
Statistics on fall injuries		National Council on Aging: NCA Falls Free Initiative - Falls Prevention Awareness Day 2018 Impact Report www.ncoa.org/resources/falls-prevention-awareness-day-2018-impact-report/
Percentage of older adults that fall annually	National	Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. 2012;(9):CD007146. www.ncbi.nlm.nih.gov/pubmed/22972103
Hospital and emergency room visits		
Hospitalizations, ED visits, and physician office visits related to heat	State	Department of Health and Human Services (HHS) sponsored by the Agency for Healthcare Research and Quality (AHRQ) - Medical Expenditure Panel Survey (MEPS). meps.ahrq.gov/mepsweb/
Medical costs		
Direct costs of fatal and non-fatal falls among older adults	National	Special report from CDC - Burns et al. www.sciencedirect.com/science/article/pii/S0022437516300172?via%3Dihub
Outcomes after intervention		
Reduction in residents reporting falls after green renovations in public housing	Local	Breysse et al. 2015 www.ncbi.nlm.nih.gov/pubmed/25679773
Incorporating injury prevention Into energy weatherization programs targeted to fall-prone elderly populations	Local	Ellen Tohn's 2019 study journals.lww.com/jphmp/Abstract/publishahead/Incorporating_Injury_Prevention_Into_Energy.99363.aspx

Table A5. Resources to monetize reduced missed days of work for building occupants

Area of focus	Level of geographic specification	Resource
Prevalence of health issue		
Low-income residents with inadequate housing	National	NCHH nchh.org/resources/policy/substandard-housing/
Percentage of income-eligible workers without sick leave	National	Institute for Women's Policy Research www.nationalpartnership.org/our-work/resources/economic-justice/paid-sick-days/no-time-to-be-sick-why-everyone-suffers.pdf
Private sector workers without sick leave	National	National Partnership for Women and Families www.nationalpartnership.org/our-work/resources/economic-justice/not-enough-family-friendly-policies.pdf US Bureau of Labor Statistics. (2018, July). Employee Benefits in the United States, Table 5, Selected Paid Leave Benefits: Access, March 2018. Retrieved 28 November 2018, from www.bls.gov/news.release/pdf/ebs2.pdf (Calculation based on 29% of 118 million private sector workers without access to paid sick days for a total of at least 34 million workers)
Wages		
Average hourly wages for renters	State and national	National Low Income Housing Coalition reports.nlihc.org/sites/default/files/oor/OOR_2019.pdf
Average earnings of employees on private nonfarm payrolls by industry sector	National	Bureau of Labor Statistics www.bls.gov/news.release/empsit.t19.htm

Appendix B. Methods to Monetize Health Outcomes

This appendix summarizes the National WAP method for monetizing the four recommended nonenergy benefits (NEBs).

NATIONAL WAP STUDY METHODOLOGIES

The following section summarizes the methodologies for six health outcomes developed from the National WAP evaluation study (Tonn et al. 2014) and a 2018 evaluation of nonenergy benefits for ComEd's low-income energy efficiency in-home program (Ma et al. 2018).

Reduced Asthma Symptoms

QUANTIFYING THE IMPACT OF WEATHERIZATION

Prior to treatment, the National Occupant Survey asked one question:

- Have you ever been told by a physician that you have asthma?

After treatment, it asked three questions:

- If the above is yes, do you still have asthma?
- During the past 12 months, did you have to stay overnight in the hospital because of asthma?
- Not counting hospitalizations, during the past 12 months, did you go to an emergency room because of asthma?

The result was that 16.8% of adults in the WAP population have asthma, and asthma-related emergency department (ED) visits and hospitalizations for all respondents reporting current diagnosis of asthma was reduced by 11.5% and 3.1%, respectively, due to weatherization.

The study also sought to monetize potential reductions in indirect costs for "high-cost" pre-weatherization asthma patients who became "low-cost" patients post-weatherization. High-cost patients are characterized by those needing medical attention less than three months after weatherization and are thus subject to many more indirect costs such as reduced housekeeping loss, loss of school and work productivity, and restricted activity. The result was that the reduction in high-cost patients was 11.8%.

MONETIZING THE BENEFIT

These additional inputs were found from reputable secondary databases:

- Average cost for hospitalizations per adult and child, and ED visit for all individuals (state specific, where available, and adjusted for inflation)
- Percentage of income-eligible with Medicare, Medicaid, Private/Other Insurance, or Uninsured (state specific where available)
- Frequency of re-admittance to hospital for adults and children, and ED visits for all individuals

- Other direct medical costs and indirect costs associated with high-cost asthma patients adjusted for inflation

Those inputs were used to help quantify benefits associated with ED and hospitalizations:

> *Benefit = (Number of persons served by WAP in PY 2008) x (Asthma prevalence for adults and children) x (Reduction in ED visits or hospitalizations) x (Frequency of re-admittance [adults and children]) x (Average hospital costs [adults and children])*

The inputs were also used to and quantify other direct and indirect medical savings for high-cost patients:

> *Benefit = (Number of persons served by WAP in PY 2008) x (Asthma prevalence for adults and children) x (Reduction in high-cost patients) x (Difference in high- and low-cost patients after extracting the ED visit and hospitalization costs already claimed)*

Reduced Thermal Stress on Occupants

QUANTIFYING THE IMPACT OF WEATHERIZATION

The National Occupant Survey asked occupants two questions:

- In the past 12 months, has anyone in the household needed medical attention because your home was too cold?
- In the past 12 months, has anyone in the household needed medical attention because your home was too hot?

They compared answers from the weatherization group before and after treatment during the study, and a comparison group that had received treatment one year prior to the weatherization group receiving treatment. The impact of treatment was calculated using the following equation:

> *Reduction in medical needs = (Pre-treatment – Post-treatment + Pre-treatment – Comparison group) / 2*

The result was that in 2008, the number of times occupants needed medical attention for cold-related stress was reduced by 1.4%, with 113 hospitalizations and 4 potential deaths prevented; and, for heat-related stress, the number was reduced by 1.1%, with 25 hospitalizations and 1 potential death prevented. The reduction for cold-climate zone data only was 0.004776%.

MONETIZING THE BENEFIT

The following additional inputs were found from reputable secondary databases:

- Percentage of hospitalizations, ED visits, and physician office visits for cold- and heat-related stress (state specific, where available)
- Average cost for each type of medical treatment including hospitalizations, ED visits, and physician office visits (state specific, where available, and adjusted for inflation)

- Percentage of income-eligible with Medicare, Medicaid, Private/Other Insurance, or Uninsured (state-specific where available)

Those inputs were used to help quantify the number of occurrences of (a) hospitalization, (b) ED visit, and (c) physician office visit avoided:

> *N (a, b, c) =* [*(Number of WAP units completed in PY 2008) x (Decreased rate of seeking medical care) x (% of type of medical treatment sought for cold and heat-related thermal stress (for a, b, and c))*]

The inputs were also used to help quantify the percentage of annual medical costs for (a, b, and c) for those with (p1) Medicare, (p2) Medicaid, (p3) Private/Other, and (p4) Uninsured or out-of-pocket payers:

> *% of annual medical costs – (for p1, p2, p3, p4) – for WAP population (for a, b, and c) = [[(% of WAP population by medical coverage type) x (% of medical costs – by payer – for population (for a, b, and c))] / (% of population by medical coverage type)]*

Finally, the associated benefit was derived as follows:

> *Benefit (without avoided deaths) = [(N (a, b, c) x % WAP medical costs (for p1, p2, p3, p4)) x Average cost for treatment (for a, b, and c)]*

MONETIZING AVOIDED DEATH BENEFIT

To incorporate the benefit of avoided deaths, we needed the following additional inputs from secondary sources:

- Number of deaths following hospitalization (state specific, where available)
- Percentage of hospitalizations resulting in deaths (state specific, where available)
- Current value of statistical life

We calculated this using two equations:

> *# of avoided deaths = [(% of hospitalizations resulting in deaths (US population)) x (# of hospitalizations prevented by WAP in PY 2008)]*

> *Total benefit of avoided deaths = [# of avoided deaths x value of a statistical life]*

Reduced Missed Days at Work

QUANTIFYING THE IMPACT OF WEATHERIZATION

The National Occupant Survey asked occupants the following questions:

- In the past 12 months, about how many days of work did you (or the primary wage earner) miss at a job or business because of illness or injury?
- In the past 12 months, about how many days of work did you (or the primary wage earner) miss because of the illness or injury of another household member?

They compared answers from the weatherization group before and after treatment during the study, and a comparison group that had received treatment one year prior to the new treatment group. The impact of treatment was calculated using the following equation:

> *Reduction in medical needs = [(Pre-treatment – Post-treatment) + (Pre-treatment – Comparison group)] / 2*

The estimated change was 0.52 fewer days missed work.

MONETIZING THE BENEFIT

The following additional inputs were found from reputable secondary databases:

- Average hourly wage (state specific, where available, and adjusted for inflation)
- Percentage of income-eligible worker without sick leave

We used those inputs to help quantify the benefit:

> *Benefit = (Number of Wx jobs completed in PY 2008) x (% of WAP households with an employed primary wage earner) x (Reduction in missed days work) x (Average hourly wage) x (8 hours/day)*

The societal and household benefit was calculated by multiplying the above result by the percentage of low-income workers with and without sick leave, respectively.

MA 2016 STUDY METHODOLOGIES

Table B1. Summary of key inputs and methodology from MA 2016 Study

Nonenergy benefit	Average reduction from survey (table 4)	Methodology
Reduced asthma	11.5%, 3.1%, and 11.8% reduction in emergency room visits, hospitalization, and the incidence of high-cost patients for asthma, respectively	Applies reported reductions to the types of and costs for medical care sought for asthma (physician office and emergency department [ED] visits, and hospitalizations) using MA-specific and national medical data adjusted for MA
Reduced thermal stress	1.9% and 2.8% reduction in the occurrence of medical care sought for cold- and heat-related illnesses, respectively	Applies reported reductions to the types and costs for medical care sought for thermal stress (physician office and ED visits, and hospitalizations) using national medical data adjusted for MA. Also estimates the avoided death benefit by assuming the same national rate of death following hospitalizations due to thermal stress (2.51% cold and 1.28% hot)
Reduced missed days at work	4.0 days	Applies reported reduction to the percentage of low-income (LI) households with an employed wage earner who does not have sick leave and national average hourly wage rate data adjusted for MA

Nonenergy benefit	Average reduction from survey (table 4)	Methodology
Reduced use of short-term, high-interest loans	6.45%	Applies reported reduction to the national average of fee and interest payments
Increased home productivity	5%	Applies reported reduction to secondary national data on losses in productivity due to sleep problems and housework-related wage rate data adjusted for MA
Reduced CO poisoning	Survey sample was too small to detect the incidence of CO poisonings and was not intended to measure avoided deaths with respect to CO monitor installation	Makes use of secondary data regarding the preventive safety impact of CO monitors on the incidences of poisonings and death, percentage of LI households using fossil fuel–fired heating systems and without a functional CO monitor, the types of and costs for medical care sought for CO poisoning (ED visits and hospitalizations) using national medical data adjusted for MA, and the VSL
Reduced home fires	Survey sample was too small to properly gauge fire frequency and consequence	Maps an extensive, LI-weighted set of fire causes (and their probabilities) found in a national fire database to the corresponding weatherization measure(s) that would have likely prevented them, and applies national medical data (for fire-related injuries) adjusted for MA and the VSL

Source: MA 2016 Study (Hawkins et al. 2016)