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Measuring Impacts of Energy Efficiency Programs on Participant Health and Well-Being

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This guidance document is part of a series of materials developed by ACEEE in 2021 for a network of program administrators exploring opportunities to incorporate health into energy efficiency programs. For more information, contact Christine Gerbode (Health and Environment program; cgerbode@aceee.org.)

This document helps administrators of residential energy efficiency programs consider and answer the following questions:

- Why should we measure and quantify the health impacts of our program?
- What health impacts can we measure?
- How can we measure the health impacts of our program?

Tips on how to start measuring health impacts are also included.

Energy-efficient home upgrade programs impact the health and well-being of a home's residents. Documenting these impacts can attract financial and professional support, ensure that programs are offering effective services, and communicate a program's benefits.

WHY SHOULD WE MEASURE AND QUANTIFY THE HEALTH IMPACTS OF OUR PROGRAM?

Improve program outcomes. Documenting health outcomes provides data that program administrators can use to identify opportunities to improve program performance and highlight approaches that are successful in the communities they serve, providing an opportunity to track changes in participant health, avoid unintended outcomes, and improve program impacts over time.

Attract new funding. The ability to demonstrate health outcomes can position a program to leverage dollars and resources from new sources, for example, those earmarked for preventive approaches to healthcare. Successfully demonstrating positive outcomes can help a program stand out in a competitive funding environment.

Build partnerships. Demonstrating health-related program impacts can help attract health-sector partners that can provide resources to support expanded program scope, outreach, and outcomes.[1]

WHAT HEALTH IMPACTS CAN WE MEASURE?

Existing energy efficiency programs measure a variety of outcomes related to health, which we group here into two broad categories:

- indicators that predict health and wellness outcomes
- direct measures of human health and wellness

Indicators that predict health and wellness outcomes. Some aspects of program impact on participant health are difficult to directly measure or observe, but benefits may be inferred from the presence of certain conditions within a home. Among health professionals, these living conditions that can affect health are referred to as *social determinants of health* (SDOH)[2]. SDOH are commonly recognized as having a greater impact on health outcomes than healthcare itself.[3] The CDC groups the SDOH into five broad categories, many of which can be affected by energy efficiency programs. Figure 1 lists SDOH within these categories; starred indicators are some of those that

might be affected most directly by energy efficiency programs, including conditions of the built environment, energy burden, housing stability, community job opportunities, and financial stability (including by reducing so-called "heat or eat?" dilemmas).

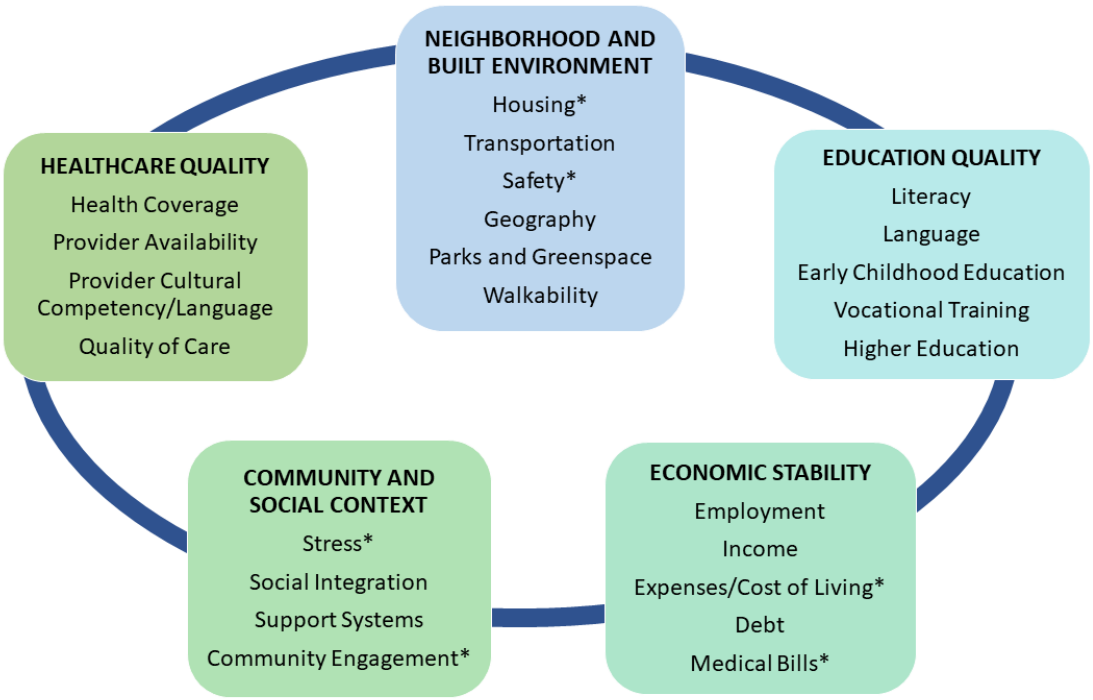

Figure 1. Examples of social determinants of health across the five categories denoted by the CDC. Asterisks indicate determinants that may be impacted by energy efficiency programs. Listed determinants modified from Kaiser Family Foundation issue brief.[4]

Many programs already gather data about health and safety measures they install. The presence or absence of working, well-maintained technologies provides valuable information about possible health or safety risks. Programs might track the presence of adequate ventilation equipment; working smoke detectors, carbon monoxide monitors, and/or radon monitors; structural repairs to improve home safety; remediation of hazards such as mold and other contaminants; and repair or replacement of dangerous furnaces. A history of maintenance and upkeep of key household appliances and systems, from electrical wiring to water heaters and stoves, can also highlight potential safety hazards and areas for improvement. Documenting and tracking these activities is a simple place to start and requires a minimal level of effort by programs.

Many programs go further and measure physical, chemical, and biological factors in the home that can influence health outcomes. Examples of these factors include indoor air quality, including temperature, humidity, and condensation, levels of pollutants such as particulate matter, volatile organic compounds (VOCs), radon, carbon monoxide, and others; biological allergens or disease triggers, including debris and allergens from mold, mildew, insects, rodents, and other pests; and irritants related to participant behavior and lifestyle, including tobacco smoke and pet-related allergens. The most commonly measured indicators in this group are carbon dioxide and ventilation rates, followed by the presence of insects, rodents, dampness, smoke, and mold.[5]

Direct measures of human health and wellness. Energy saving programs that improve indoor environmental conditions can help reduce symptoms and frequency of asthma, chronic obstructive pulmonary disease (COPD), thermal stress, fatigue, trips and falls, and other physical and mental health stresses.[6] Some programs already track certain indicators that may reflect these improved health outcomes. The following are examples:[7]

- Days of school missed
- Days of worked missed
- Hospital admissions
- Emergency room visits
- Visits to the doctor
- Calls to the doctor
- Asthma symptoms
- Uncontrolled asthma
- Prevalence of other respiratory illnesses

Of these, asthma symptoms and uncontrolled asthma combine to be the most commonly tracked indicator in this group, followed by comfort, emergency room visits, and other respiratory illnesses.[8] Methods for measuring these indicators are discussed later in this document. In general, however, these are self-reported measurements, collected directly from participants by survey or interview rather than with technical equipment. Metrics related to frequency of medical care or specific services might also be obtained directly from participants' healthcare providers.[9]

How can we measure the health impacts of our program?

There are a variety of methods to measure impacts, and many programs employ more than one. Common methods for measuring health impacts include:

Surveys/Interviews. Surveys and interviews enable programs to collect self-reported information from participants about both direct human health outcomes and environmental conditions. These methods typically involve asking a series of questions in person, by phone, online, or in a paper format. Surveys can provide tailored information about a participant's health status without having access to medical records, but they must be thoughtfully designed to elicit accurate, useful, and complete results. Surveys may be conducted before the intervention and then at intervals after the intervention to see how outcomes have changed.

Environmental Testing. Environmental testing is the measurement of specific conditions that can influence occupant health. This may include air quality testing for pollutants such as particulate matter, radon, carbon monoxide, nitrogen oxides, and VOCs. It also includes testing of ventilation rates, temperature, humidity, and mold. These measurements can show changes to the home environment that might be attributed to program services. An important consideration when taking environmental measurements is that participant behavior can act as a variable or influence measurements of specific conditions.

Visual Inspection. A visual inspection of a home might identify the presence or absence of certain technologies, such as smoke detectors and working thermostats. Visual inspections might also be used to identify health risks such as pests, moisture or mold, injury risks like loose carpets or broken stairs, malfunctioning appliances, or other deficiencies that could threaten health and/or safety.

Modeling. Some programs forecast or estimate the health impacts of their work based on well-documented relationships between energy use, pollution, human health, and other factors. Various research groups and government agencies, including the U.S. Environmental Protection Agency (EPA), provide modeling tools and software to help perform the calculations needed to create these forecasts or estimates. For example, a program might track energy usage in a home before and after a project or intervention; these measured energy savings could be input into an EPA model to estimate how much air pollution was avoided as a result of reduced fossil-fuel production demand at regional power plants due to the change in energy use at the treated home. These estimates of avoided pollution could then be used to estimate some of the resulting public health benefits.

Table 1. Descriptions, Benefits, Challenges, and Additional Resources Related to Basic Methods of Health Impact Assessment

Method	Benefits	Challenges
Surveys / Interviews	Surveys and interviews can identify many of the health impacts that a medical record might show, but without having to navigate the privacy protections and other barriers of medical records. They can also be completed remotely without the need for staff to visit homes. They can reach larger audiences and can be designed to be completed rapidly.	Since both surveys and interviews are based on self-reported metrics, they may have inaccuracies and/or biases. Depending on the method of delivery, including factors related to the relationship between the person conducting the survey and the person responding, response rates may be low and additional complications may arise. Participant follow-up can be important to survey integrity. Experts knowledgeable about design and administration of these methods may be needed.
Environmental Testing	These measurements can show changes to the home environment that might be attributed to program services, if measurements are taken before and after program services are provided. The data can be used in a wide range of analyses, depending on the audience. The data is less likely to be subject to the issues of bias that surveys may face.	Environmental testing requires in-home measurement, as well as the use of proper equipment. Specialists that are trained to complete the testing are needed. Results indicate changes to the environment, not direct health impacts.
Visual Inspection	A visual inspection can be used to quickly identify hazards and risks. When done pre- and post- intervention, programs can measure changes in these observations as indicators of reduced risks and harmful exposures. Visual inspections can be easily integrated into existing home visits at a low cost, and may give program administrators insight into additional needs of participants.	Results indicate healthfulness of an environment, but not direct health benefits of a program.
Modeling	Models can be very effective in illustrating the links among various program services, outcomes, and impacts, including between the environmental, climate, and human health impacts of a program. They may be helpful in presenting the potential value of a program, especially the potential value of further growth or additional services.	Models are estimations based on assumptions and can therefore be non-specific and inaccurate. They may require specialized skills or expertise to run, and can be expensive to create or run. Moreover, these methods are limited by the quality of the data and strength of the known relationships used to construct the model in question. Models may require large data sets to be effective.

GETTING STARTED

Currently no industry-standard approaches to collecting data concerning the health impacts of energy efficiency programs exist. Program administrators might consider some of the following approaches:

Conduct a pre-intervention or baseline assessment. Programs can borrow from existing examples to design a baseline assessment of the home and/or occupant health.[10]

Conduct a post-intervention assessment. Programs seeking a low-cost way to assess occupant health after an intervention can use participant surveys. Simple surveys can be created or adopted from other programs or agencies.[11] Data from a post-intervention assessment may be more compelling in combination with data from a pre-assessment, or data collected at other additional timepoints.

Collect data on multiple indicators that align with program goals. ACEEE research indicates that most programs track a minimum of three separate health indicators, and that more robust efforts incorporate ten or more indicators. Health indicators tracked should align with program goals and services provided. At a minimum, document any program repair actions and/or measures installed that have intended health and safety benefits. Beyond that, programs can directly measure certain impacts. For programs that target ventilation and air filtration, for example, administrators may measure changes in levels of carbon monoxide, radon, and particulate matter. If a program targets air sealing, it may make more sense to track pest prevalence, humidity levels, presence and levels of radon, and mold exposure. The most common type of indicators collected by programs are direct measurements of human health and wellness; across that category of indicator, data on asthma and occupant comfort are most frequently collected.

Directly measure human health and wellness. The ability to document quantifiable changes in the health of program participants is one of the clearest ways to demonstrate a program's health impact (in contrast to inferring or predicting health impacts). This approach can be employed at a relatively low cost by making use of existing surveys.

Program administrators may find the following steps useful for developing a plan that measures program health impacts:

Step 1. Identify and engage the audience

Think about who you will be reporting these findings to—who is your audience, and who is the impact evaluation for? Potential funders? Health partners? Prospective participants? Knowing your intended audience and their likely priorities can help guide which metrics to measure, what methods to use, and how to most effectively report the findings. Engaging with the target audience will provide valuable information concerning opportunities, preferences, needs, and pitfalls to take into consideration in program design and communication of impacts.

Step 2. Define the goals and scope of the effort

Identifying a purpose for tracking health outcomes can help determine the best methods and appropriate level of rigor for collecting and handling the data. Select goals that reflect your available resources, such as the availability of staff to manage the effort, budget, equipment, and access to technologies used to evaluate environmental conditions or assess health. The following are examples of goals:

- Collecting data to better demonstrate the benefits of your services to potential participants
- Aligning program elements with city or other agency priorities concerning low-income and underserved communities
- Establishing the potential return on investment or value proposition of your services, as part of a business pitch for pursuing additional funding
- Documenting health impacts for the purpose of developing partnerships with health-focused organizations

Step 3. Select your methods for data collection

Create a strategy and select your methods for conducting your assessment. The type of method should be informed by the limitations and resources available for your program. Staffing capacity and expertise, funding, and availability of equipment are all important considerations. Decide whether you will need staff training or outside experts to carry out the methods you choose. Obtain any necessary equipment. A few trial runs of your data collection protocol may help you identify and solve potential problems prior to a full-scale implementation.

Step 4. Collect your data

As you implement your data collection plan, be mindful of how your data will be tracked and analyzed. Build in time and resources to process in ways that make what you are reporting useful for communicating with your target audience. Consider formats for reporting (tables, reports, fact sheets, emails, brochures, etc.), storage protocols, or other standards you can put in place to make working with this data easier, either now or in future if it needs to be revisited.

Step 5. Analyze and report findings

Before analyzing and reporting findings, consider your audience and your goals—does your audience have a preferred method for reporting? This will help determine what you report and how you choose to report it. For example, audiences may find stories and specific examples related to affected participants to be compelling, in which case program impacts might best be reported in the form of case studies or complemented with other storytelling formats. Other audiences may be most interested in the business case implications of a program's health impacts and look for monetized values of avoided health harms. Program administrators can quantify the monetary value of health harms avoided by the services they provide by inputting key measurements (e.g., number of households reached and number of health harms avoided) into an equation to monetize their estimated program impacts.[12] Monetized health benefits can be persuasive evidence for conveying program impacts to health audiences.

Step 6. Refine and improve program based on findings

Measuring impact is an important step to check in on your progress and build accountability. Your results can help identify strengths and weaknesses of your program and opportunities to change program design, delivery, and evaluation processes. You may be able to use the results to identify opportunities to minimize unintended consequences and more effectively meet the needs of communities you serve.

Additional Reading and Resources

EPA and DOE Documentation on Assessing and Implementing Health Interventions in Homes

- EPA (Environmental Protection Agency). 2014. Healthy Indoor Environment Protocols for Home Energy Upgrades. www.epa.gov/sites/production/files/2014-12/documents/epa_retrofit_protocols.pdf.

Compilation of in-home assessment methodologies for various health harms

- HUD (Department of Housing and Urban Development). 2012. *Healthy Homes Issues: Residential Assessment*. hud.gov/sites/dfiles/HH/documents/HUD_Residential_Assessment_Paper_12-11-12.pdf

Sample environmental health assessment structured around Healthy Homes principles

- Children's Mercy Hospital. 2010. *Level I Environmental Health Assessment*. live-bpidev.pantheonsite.io/sites/default/files/Healthy%20Home%20Assessment%20Field%20Report%20-%20with%20Education%20Pages.pdf.

Sample pre-intervention assessment checklist

- CDC (Centers for Disease Control and Prevention), Department of Health and Human Services, Department of Housing and Urban Development, and Environmental Protection Agency. 2018. *Home Characteristics and Asthma Triggers Checklist for Home Visitors.* aceee.org/sites/default/files/pdfs/epa_asthma_home_environment_checklist.pdf.

Sample post-intervention assessment survey

- Tennessee Valley Authority, Three Cubed, and the University of Tennessee. *Non-Energy Impacts of the Home Uplift Program Survey for Residents.* aceee.org/sites/default/files/pdfs/TVA_Paper_Survey.pdf.

Additional sample assessments and resources

- Levin, E., L. Curry, and L. Capps. 2019. "Section 7.7: Energy-Plus-Health Program Resources and Sample Materials." *Energy-Plus-Health Playbook*. Winooski, VT: VEIC. www.veic.org/Media/Default/documents/resources/manuals/energy-plus-health-playbook-section7.pdf.
- National Center for Healthy Housing. Accessed 2021. *Inspections and Assessments: Reports and Guides.* https://nchh.org/tools-and-data/standards-and-assessments/inspections-and-assessments-reports-and-guides/

Report on measuring health-related impacts of programs

- 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. October 22. www.aceee.org/research-report/h1901

Report on estimating and monetizing potential health benefits of complementary health services in in-home energy efficiency programs

- 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: ACEEE. May 5. www.aceee.org/research-report/h2001.

Models for estimating health and environmental impacts

- AVoided Emissions and geneRation Tool (AVERT). U.S. Environmental Protection Agency. https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert
- CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). U.S. Environmental Protection Agency. https://www.epa.gov/cobra
- The Estimating Air pollution Social Impact Using Regression (EASIUR) model. The Center for Air, Climate, and Energy Solutions. https://www.caces.us/easiur
- Health Co-Benefits of the Built Environment. Harvard T.H. Chan School of Public Health. https://cobe.forhealth.org/

[1] For more discussion and guidance on energy and health partnerships, see the VEIC *Energy-Plus-Health Playbook* listed in the end-of-document additional resources.

[2] See the CDC's description of SDOH: https://www.cdc.gov/socialdeterminants/about.html

[3] Hood, C. M., K. P. Gennuso, G. R. Swain, and B. B. Catlin. 2016. "County health rankings: Relationships between determinant factors and health outcomes." *American Journal of Preventive Medicine* 50(2):129-135. https://doi.org/10.1016/j.amepre.2015.08.024. Modifiable health determinants studied were grouped as socioeconomic factors, health behaviors, clinical care, and physical environment; clinical care differences were estimated to account for only around 16% of studied health outcomes.

[4] Artiga, S. and E. Hinton. 2018. Beyond Health Care: The Role of Social Determinants in Promoting Health and Health Equity. Kaiser Family Foundation. http://files.kff.org/attachment/issue-brief-beyond-health-care

[5] See Hayes and Denson 2019 in the end-of-document additional resources.

[6] Wilson, J., D. Jacobs, A. Reddy, E. Tohn, J. Cohen, and E. Jacobsohn. 2016. *Home Rx: The Health Benefits of Home Performance—A Review of the Current Evidence*. Washington, DC: DOE.

[7] National averages and proxies for the monetary value of avoided healthcare costs for a variety of health harms are compiled in ACEEE's 2020 report *Making Health Count: Monetizing the Health Benefits of In-Home Services Delivered by Energy Efficiency Programs*, listed in the end-of-document resources.

[8] https://www.aceee.org/sites/default/files/publications/researchreports/h1901.pdf

[9] None of the >60 programs surveyed in Hayes and Denson 2019 had successfully obtained patient medical records. We are aware of several examples of failed attempts by programs seeking this information and are aware of no replicable models that have succeeded . . . yet.

[10] See end-of-document resources for an example pre-intervention assessment jointly issued by DHHS, HUD, and EPA, as well as other assessment tools and resources.

[11] See end-of-document resources for an example post-assessment survey used to evaluate a program run by the Tennessee Valley Authority.

[12] For more information on simple ways to estimate and monetize the value of certain in-home health interventions, see ACEEE's 2020 report on quantifying and monetizing health benefits in the end-of-document resources.

For more information on this topic or the contents and development of this document, please reach out to Christine Gerbode (ACEEE Health and Environment program) at cgerbode@aceee.org.