Assessing the Health Impacts and Benefits of Regional Climate Action Plan Strategies in Western Massachusetts

A COLLABORATIVE ASSESSMENT BY THE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH, THE PIONEER VALLEY PLANNING COMMISSION, AND THE MUNICIPALITIES OF SPRINGFIELD AND WILLIAMSBURG

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EXECUTIVE SUMMARY

Introduction

The goals of public health to prevent injury and disease, reduce potential risks, enhance emergency preparedness, and increase the resiliency of communities provide the foundation for an effective public health response to climate change. The Health Impact Assessment (HIA) framework can provide a tool to integrate public health considerations into community-based adaptation planning efforts. HIAs use data, research, and stakeholder input to determine a proposed policy, plan or project's impact on the health of a population, and provide recommendations to address these impacts. This HIA— which focused on the communities of Springfield and Williamsburg— explored an overall approach for supplementing proposed climate change action strategies with information on the public health impacts and benefits of these strategies. A long-term goal of this effort is to provide a roadmap for other municipalities and regional agencies to consider health in their climate adaptation planning process.

This HIA represents a collaborative effort by the Massachusetts Department of Public Health (DPH), the Pioneer Valley Planning Commission (PVPC), and the municipalities of Springfield and Williamsburg. It is based on the regional Pioneer Valley Climate Action and Clean Energy Plan completed by the PVPC in 2013. The aim of that plan was to promote greater understanding of the causes and consequences of climate change in PVPC's service region (which includes Springfield and Williamsburg) and to identify a set of actions that local governments and other partners could consider to mitigate and adapt to climate effects.

Because of the limited resources and time constraints of this effort, the HIA should be viewed as an entry point to support more comprehensive HIAs that could be undertaken at the local level.

An Advisory Committee of stakeholders identified two climate action strategies from the PV Climate Action Plan to be evaluated in the HIA: (1) provide cooling centers and other approaches to assist vulnerable populations during heat-related events and (2) implement energy efficiency measures in municipal buildings.

Advisory Committee

Charlene Nardi
Williamsburg Town Administrator

Donna Gibson
Williamsburg Board of Health

Gerald Mann
Williamsburg Energy Committee

Nicole Bourdon
Springfield Department of Health and Human Services

Highlights of the Scoping and Assessment phases of the HIA including the literature reviews, formulating and addressing research questions, developing pathway diagrams, and assessing the distribution of health impacts and benefits of each strategy are summarized below.

Summary of Literature Review

Heat-related Events

- According to the National Climate Assessment, the Northeastern climate is experiencing noticeable changes that are expected to increase in the future. Between 1895 and 2011, temperatures rose by almost 2°F, and projections indicate warming of 4.5°F to 10°F by the 2080s. As the global climate continues to change, extreme heat events are predicted to occur more frequently and heat-related morbidity and mortality is expected to rise.

- The ability to reduce exposure to heat during extreme events, especially for vulnerable populations, will be an increasingly important health determinant. Elderly people living alone are especially vulnerable. For example, during the European heat wave of 2003, many of the excess heat-related deaths in France were elderly people.

- Chronic medical conditions (e.g., diabetes, renal disease, cardiovascular disease, respiratory disease) increase vulnerability to heat, especially among elderly people. Lack of mobility and mental illness also reduces a person's ability to respond to the heat.

- Coordination between local police and fire, human services, public health, emergency medical services, and local hospitals is essential for preventing heat-related morbidity and mortality among the most vulnerable populations.

- Cooling centers should be located in areas that are accessible to the most vulnerable populations and should be advertised in a way that targets those populations.

Energy efficiency

- Energy efficiency measures reduce electricity demand through improvements in end-use technologies in the residential, commercial, industrial and manufacturing sectors. In addition to reducing energy consumption and related costs, energy efficiency measures also benefit the public health by reducing emissions of greenhouse gas and air pollution emissions and increase the reliability of the energy grid. . In addition, by reducing dependence on foreign sources of fuel, energy efficiency makes an important contribution to increased energy security.

- An expert report on energy efficiency by the UN Foundation (2007) concluded that strategies that emphasize energy efficiency are the most economically and environmentally sensible way of meeting the twin objectives of providing energy for sustainable development and addressing climate change.

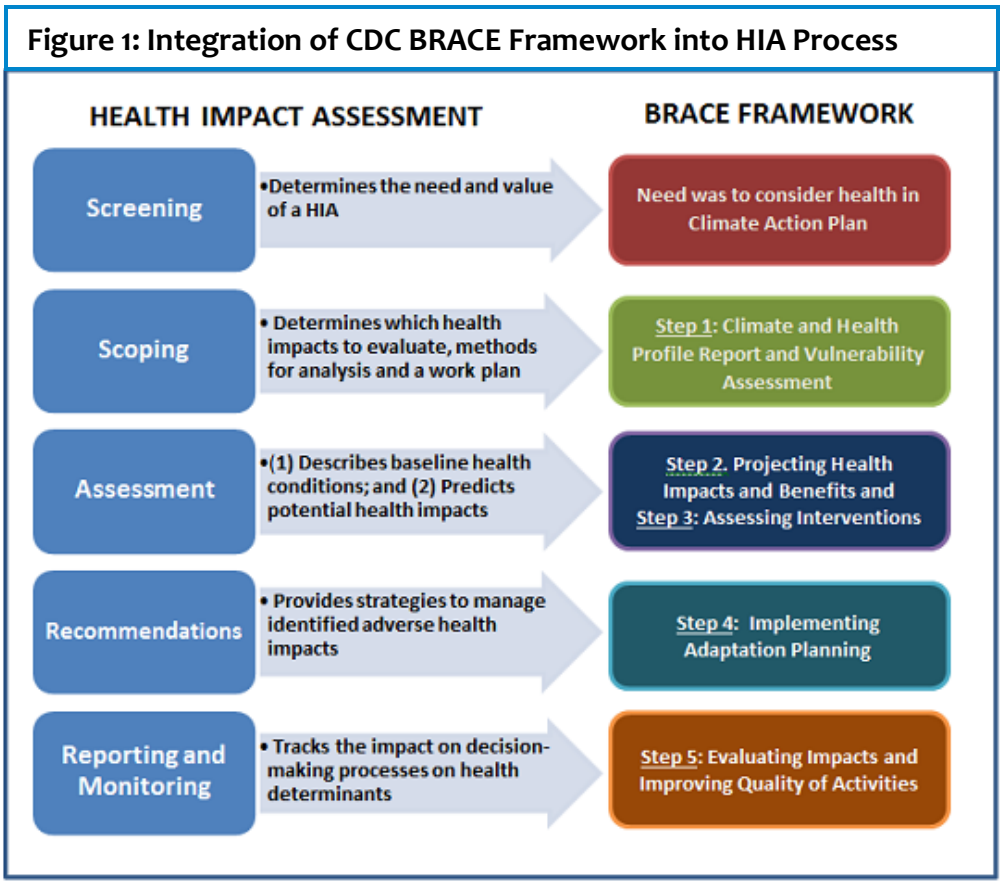
- According to the US EPA, state and local government agencies across the US spend more than $10 billion a year on energy to provide public services and meet constituent needs.

- Improving the building envelope is a strategy often used to improve energy efficiency by preventing excess heat from escaping, but the potential negative effects on indoor air quality need to consider adequate ventilation rates.

Pathway Diagrams

The goal of a pathway diagram is to visually demonstrate the link between the proposed policy, plan or project and potential health outcomes. Literature reviews and input from the Advisory Committee informed the development of the pathway diagrams. The pathway diagrams illustrate an innovative approach used in this HIA to connect the HIA framework with Step 1 of the Centers for Disease Control and Prevention (CDCs) Building Resilience Against Climate Effects (BRACE) framework. The BRACE framework is a five-step process that allows health officials to develop strategies and programs to help communities prepare for the health effects of climate change. Figure 1 illustrates how Step 1 of the BRACE framework, including climate change impacts, the populations and systems most vulnerable to these impacts, and the associated health effects, were integrated into the assessment phase of this HIA.

Figure 1: Integration of CDC BRACE Framework into HIA Process



Two pathway diagrams were prepared for this HIA: Figure 2 presents the potential health impacts associated with providing cooling centers and other approaches to assist vulnerable populations during heat-related events. The assessment of this pathway focused on projected increases in the frequency and intensity of heat-related events, characterization of vulnerable populations in each community, evaluation of existing heat response plans in each community, and mapping the location of existing cooling centers.

FIGURE 2: PATHWAY DIAGRAM FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS

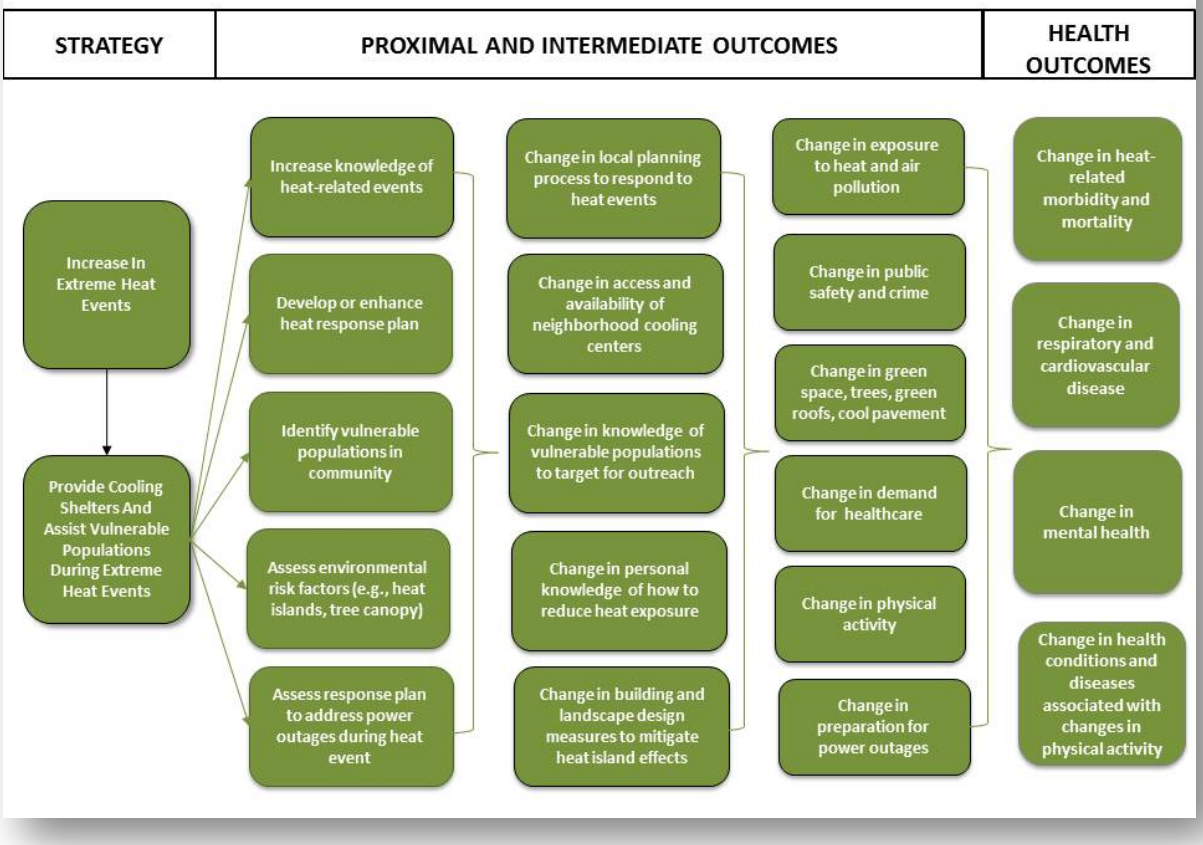
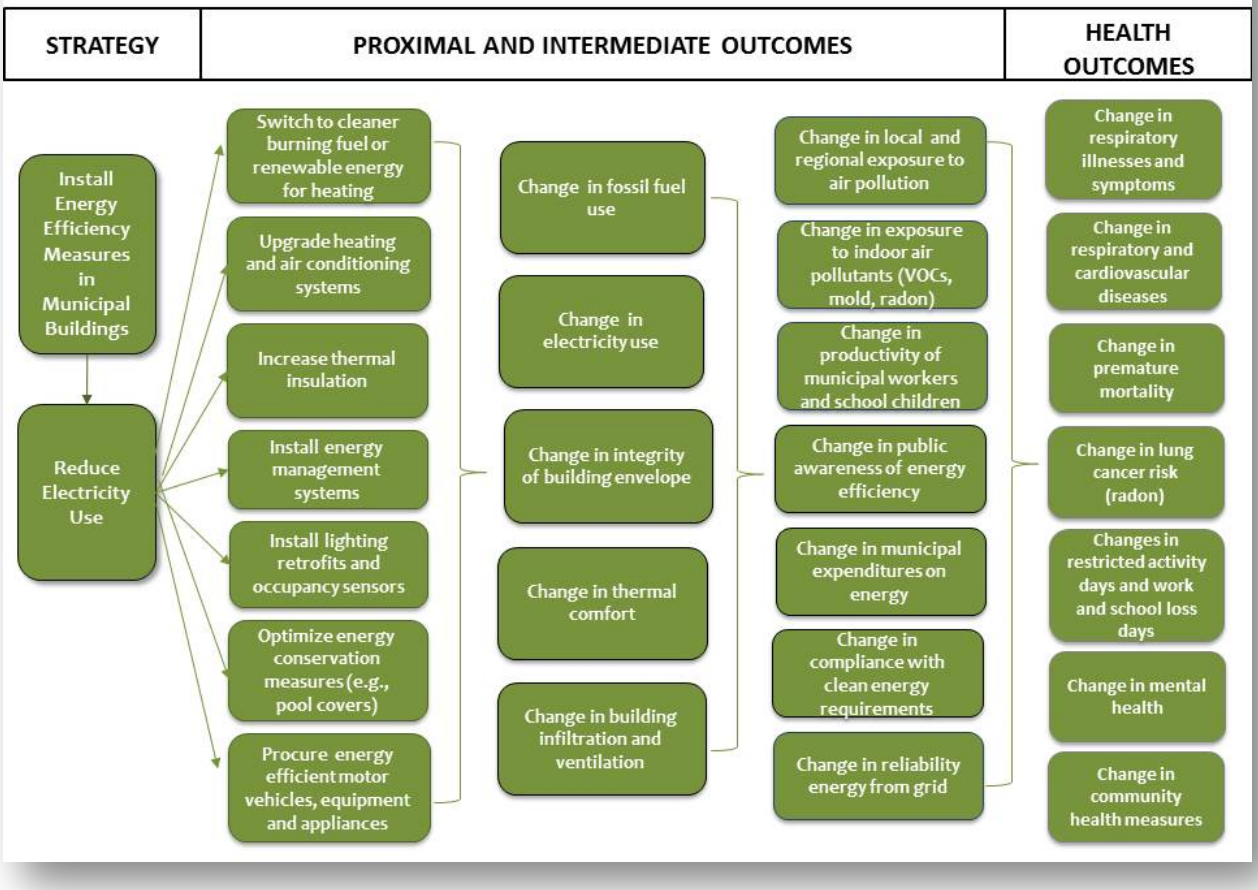


Figure 3 presents the potential health impacts of implementing energy efficiency measures in municipal buildings. In addition to assessing potential climate and vulnerability impacts, the assessment of energy efficiency measures included semi-quantitative analysis of changes in local and regional air pollution emissions from reductions in electricity in each community.

FIGURE 3: PATHWAY DIAGRAM FOR IMPLEMENTING ENERGY EFFICIENCY IN MUNICIPAL BUILDINGS



Major Findings of the HIA

- Overall, the HIA found that while designing appropriate research methods for evaluating specific climate action strategies can be challenging, health impact assessments can be an effective tool to convene municipal stakeholders, evaluate baseline health conditions, and qualitatively assess the health implications of mitigation and adaptation strategies at the local level.

Heat-related Events

- The climate action strategy to provide cooling centers and other approaches to assist vulnerable populations was found to likely reduce heat-related morbidity and mortality.

- For heat-related impacts, baseline health conditions in Springfield (e.g., higher prevalence of respiratory diseases and diabetes in adults, pediatric asthma in children) indicate that the health co-benefits of this strategy may be substantial. Baseline health profiles in Williamsburg indicate fewer adverse health conditions.

- While there are significant differences in the baseline health profile of Springfield compared to Williamsburg in terms of poverty, population density, and people of race/ethnicity other than White, the relative percent of one category of vulnerable residents - elderly living alone (i.e., 1 in 3)- is the same in both communities. Thus, the common issues and resource constraints shared by both the large urban city and small rural town in developing and activating a heat response plan, including education and outreach to vulnerable populations, as well as taking steps to mitigate environmental risk factors through changes in building and landscape design measures (e.g., lack of trees and green space, impervious surfaces) may be more effectively addressed through regional efforts.

- A key issue raised by stakeholders is the potential loss of power at cooling shelters during an extreme heat event. Given the regional nature of the electrical grid, this issue should also be considered in future regional planning efforts.

Energy Efficiency

- In addition to cost-savings, energy efficiency programs provide a wide range of health, environmental, and social co-benefits that reduce negative health impacts and improve the resiliency of communities.

- Energy efficiency improvements to buildings have positive co-benefits with respect to improving the indoor environment for building occupants and reducing outdoor air pollution from the electrical power grid across several states. US EPA model estimated that the monetized benefits of avoided health impacts of displaced emissions from energy efficiency measures implemented in Springfield ranged from $760,000-$1,700,000.

- While the overall health impacts from implementing energy efficiency measures in municipal buildings are positive, the need to achieve and maintain adequate ventilation for acceptable indoor air quality must also be considered. It is also important to consider the potential increase in indoor radon levels from energy efficiency measures.

- The assessment also suggests that energy efficiency measures can increase productivity of building occupants (e.g., municipal workers and students). These activities also increase public awareness and empowerment to address energy issues and climate change at the local level. The HIA demonstrated that although the co-benefits at the municipal level may be relatively small, the total benefits regionally and statewide of such actions are likely significant and need to be further assessed.

- A key feature of this HIA is the integration of an evidence-based framework developed by Centers for Disease Control and Prevention's (CDC) Climate and Health Program (Building

Resilience Against Climate Effects or BRACE) to support the advancement of health-based climate change adaptation strategies. Evaluation of the approach for integrating the BRACE framework into the appropriate phases of the HIA found that (1) the approach addressed one of the goals of the HIA to collect and analyze the evidence between climate change planning and health; and (2) the approach informed the assessment phase of the HIA by providing evidence-based data on climate impacts, health outcomes of greatest concern, and identification of populations potentially vulnerable to climate impacts.

Table 3 and Table 4 provide the overall summary including major assumptions and limitations/uncertainties of the assessment of climate action strategies to provide cooling centers and other approaches to assist vulnerable populations during heat-related events and to implement energy efficiency in municipal buildings, respectively.

Impact refers to whether the alternative will improve (+), harm (-), or not impact health or unknown (+/-).

Magnitude reflects a qualitative judgment of the size of the anticipated change in health effect (e.g., the increase in the number of cases of disease, injury, adverse events): Negligible, Minor, Moderate, and Major.

Severity reflects the nature of the effect on function and life-expectancy and its permanence: High = Intense/severe; Mod = Moderate; Low = Not intense or severe.

Strength of Causal Evidence refers to the strength of the research/evidence showing causal relationship between strategies and the health outcome: ♦ = plausible but insufficient evidence; ♦♦ = likely but more evidence needed; ♦♦♦ = high degree of confidence in causal relationship. A causal effect means that the effect is likely to occur, irrespective of the magnitude and severity.

TABLE 3: OVERALL HEALTH ASSESSMENT FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS DURING HEAT-RELATED EVENTS

PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATION						
HEALTH OUTCOMES	**Impact**	**Magnitude**	**Severity**	**Strength of Causal Evidence**	**Assumptions**	**Limitations / Uncertainties**
Change in heat-related morbidity and mortality	+	Moderate	High	♦♦♦	Municipalities will develop/enhance and implement a heat response plan that includes planning for vulnerable residents; and education and outreach on reducing heat exposure during heat events.	Information on existing use of centers is needed; Impact of power outages during heat-related events is unknown.
Change in respiratory and cardiovascular diseases	+	Major	Moderate	♦♦♦		
Change in mental health	+	Unknown	Unknown	♦♦	Municipalities will begin a dialogue about how to address environmental risk factors (e.g., heat island, tree canopy) through changes in building and landscape design measures. Increased physical activity is a co-benefit of these actions.	Insufficient data on mental health effects and future study is recommended. Planning and implementation of design measures is required.
Change in health conditions/ diseases from increased physical activity	+/-	Unknown	Unknown	♦♦♦		

TABLE 4: OVERALL ASSESSMENT OF IMPLEMENTING ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS

IMPLEMENT ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS						
HEALTH OUTCOMES	**Impact**	**Magnitude of those Exposed**	**Severity**	**Strength of Causal Evidence**	**Assumptions**	**Limitations / Uncertainties**
Respiratory illness and symptoms	+	Moderate	High	♦♦♦	Improved indoor air quality in schools and municipal buildings including compliance with ventilation guidelines.	The magnitude of the outdoor air quality impact from reduced use of heating oil is uncertain.
Respiratory and cardiovascular diseases	+	Major	High	♦♦♦	Reductions in regional air pollution from displaced electricity at electric generating units (EGUs) occur at specified units.	A major limitation of US EPA's model for quantifying benefits of air pollution reductions is that it underestimates total benefits because it only includes secondary formation of $PM_{2.5}$ from NOx and SOx emissions.
Change in premature mortality	+	Major	High	♦♦♦		
Change in lung cancer risk	+/-	Unknown	Unknown	♦♦♦	Indoor radon levels vary across municipalities.	Pre- and post-monitoring is needed. Energy efficiency measures may increase or decrease indoor radon levels.
Restricted activity days and work/school loss days	+	Major	Moderate	♦♦	Increased productivity of workers and students from improvements from energy efficiency measures including improved indoor air quality and lighting.	Surveys are needed. Limited studies from California of post-retrofit benefits in school children; no data on municipal workers.
Change in mental health	+	Unknown	Unknown	♦♦	Improved work/school environment. Public awareness and empowerment to address energy issues and climate change at the local level	Stakeholders provided evidence of positive responses from residents.
Change in community health measures	+	Unknown	Unknown	♦	Shift in municipal expenditures from energy to other uses; increase market value of municipal buildings	Impact of energy efficient buildings on market value of municipal assets is unknown.

Proposed Recommendations:

General Recommendations

- Regions and municipalities statewide without climate action plans should take steps to prepare such plans.
- State, regional, and local agencies should coordinate to provide data and other resources for continued research and action on the relationship between climate and health.
- Other recommendations made in the Pioneer Valley Action and Clean Energy Plan should be examined to better understand health impacts and benefits.
- Tools, innovative methods, and approaches to conduct comprehensive HIAs should be identified to more fully explore health impacts and benefits of adaptation strategies.

Providing Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

- Develop heat response plans that includes information about vulnerable populations (e.g., elderly, elderly living alone, socially isolated, children, people without a car, economically disadvantaged); placement of cooling centers within easy access to these populations; and personal strategies and solutions for cooling at home during a heat-related event, especially where air conditioning is not available or when the power goes out.
- Implement community-wide mitigation efforts, such as improving building and landscape design standards, ensuring a tree canopy and minimizing pavement to reduce urban heat islands.
- Promote regional planning efforts that would support consistent educational materials and outreach to vulnerable populations, address environmental risk factors, identify critical indicators (e.g., heat islands, tree canopy), and identify solutions to potential loss of power at cooling shelters during an extreme heat event.

Proposed Recommendations for Implementing Energy Efficiency Measures in Municipal Buildings

- Ensure that ventilation systems maintain good air quality. Consideration of the Massachusetts Department of Public Health guideline for indoor air quality will ensure

optimal indoor environmental conditions. Specifically, the guideline recommends a ventilation rate of 20 cubic feet per minute (cfm) of fresh air to provide optimal air exchange resulting in carbon dioxide levels at or below 800 ppm.

- Implementation of energy efficiency measures by municipal governments may be a viable approach of "Lead by Example" to encourage residents to take steps to support energy efficiency in their homes. One option is to support such efforts by shifting budget expenditures from reduced electricity use to support additional energy efficiency programs.

- The stakeholder process identified the need to better understand and measure community awareness around climate action and how municipal actions can spur empowerment. Changes in awareness and sense of empowerment across municipal workforce and community residents of the value of municipal energy efficiency programs is the cornerstone of state and local government initiatives such as Leading By Example. This recommendation is supported by a large body of work demonstrating the benefits of incentivizing energy efficiency programs.

- Radon testing should occur prior to and after renovations of a building to determine if mitigation measures are warranted and can be incorporated during the renovation. Post-renovation testing should be conducted to ensure mitigation measures were successful.

- Support municipal efforts to apply for Massachusetts Department of Energy Resources (DOER) Resiliency funding to ensure hospitals and other essential facilities have power during outages.

- Support continued state funding of energy efficiency measures at the local level.

- Given that energy efficiency is the most practical policy option to mitigate and adapt to climate change impacts, it is important that the co-benefits of energy efficiency be promoted at all levels (i.e., individual, municipal, regional and statewide).

Areas of Future Research

- Build on work by the Michigan Department of Community Health's Climate and Health Adaption Program that found evidence that adequate tree canopy has multiple benefits such as decreased heat and air pollution exposure, and increased physical activity, which directly benefits the general population and specifically those individuals with pre-existing diseases including diabetes, hypertension, and obesity.

- Improve the understanding of community awareness around climate actions and how municipal actions can spur empowerment for more system wide change. This may include strategies that educate residents about the problem, provide information on necessary

behavioral changes to address the problem, promote transparency about sustainability issues, and facilitate consumer's individual choices toward sustainable patterns.

- Poverty and crime have both been correlated with excessive morbidity and mortality during heat waves. The percentage and number of people living in poverty are much higher in Springfield than in Williamsburg, indicating that the vulnerable population is larger. There is also a significant difference in the number of violent crimes in the two communities. Further examination of the relationship between poverty, crime and successful climate adaptation strategies is needed.

- Power outages were identified as a major concern by municipal officials in Springfield and Williamsburg. Analysis of power outages is conducted by the utility industry and consultants. Given that this information would be useful in the planning process, requests should be made for this information at the regional level.

- In addition to the cost-saving, the co-benefits of energy efficiency measures need to be further assessed. For example, there was limited information on the health and performance benefits of lighting retrofits on both school children and municipal workers. In addition, while the US EPA identified possible benefits of removing PCB fluorescent light ballasts, this activity could increase risk if containment and removal actions are inadequate.

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EXECUTIVE SUMMARY

Introduction

The Health Impact Assessment (HIA) framework provides a tool to integrate public health considerations into community-based adaptation planning efforts. HIAs use data, research, and stakeholder input to assess a proposed policy, plan or project's impact on the health of a population, and provide recommendations to address these impacts. This HIA — which focused on the communities of Springfield and Williamsburg — explored an overall approach for supplementing climate change action strategies with information on the public health impacts and benefits of these strategies.

Because of the limited resources and time constraints of this effort, this HIA should be viewed as an entry point to support more comprehensive HIAs that could be undertaken at the local level. A long-term goal of this initial effort is to provide a roadmap for other municipalities and regional agencies to consider health in their climate adaptation planning process.

This HIA represents a collaborative effort by the Massachusetts Department of Public Health (DPH), the Pioneer Valley Planning Commission (PVPC), and the municipalities of Springfield and Williamsburg. The climate action strategies are based on the regional Pioneer Valley Climate Action and Clean Energy Plan completed by the PVPC in 2013. The aim of that plan was to promote greater understanding of the causes and consequences of climate change in PVPC's service region (which includes Springfield and Williamsburg) and to identify a set of actions that local governments and other partners could consider to mitigate and adapt to climate effects.

An Advisory Committee of stakeholders identified two climate action strategies from the PV Climate Action Plan to be evaluated in the HIA: (1) providing cooling centers and other approaches to assist vulnerable populations during heat-related events and (2) implementing energy efficiency measures in municipal buildings.

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Highlights of the HIA including evaluating the scientific literature, formulating and addressing research questions, developing pathway diagrams, and assessing the distribution of health impacts and benefits of each strategy are summarized below.

Summary of Literature Review

Heat-related Events

- According to the National Climate Assessment, the climate in the Northeast is experiencing noticeable changes that are expected to increase in the future. Between 1895 and 2011, temperatures rose by almost 2°F, and projections indicate temperature increases of 4.5°F to 10°F by 2080. As the global climate continues to change, extreme heat events are predicted to occur more frequently and heat-related morbidity and mortality is expected to rise.

- The ability to reduce exposure to heat during extreme events, especially for vulnerable populations, will be an increasingly important health determinant. Elderly people living alone are especially vulnerable. For example, vulnerability factors associated with mortality during the 1995 Chicago heat-related event were elderly living alone, not leaving home daily, lacking access to transportation, and not having an air conditioner.

- Chronic medical conditions (e.g., diabetes, renal disease, cardiovascular disease, respiratory disease) increase vulnerability to heat, especially among elderly people.

- Coordination between local police and fire, human services, public health, emergency medical services, and local hospitals is essential for preventing heat-related morbidity and mortality among the most vulnerable populations.

- Cooling centers should be located in areas that are accessible to the most vulnerable populations and should be advertised in a way that targets those populations.

Energy efficiency

- Energy efficiency measures reduce electricity demand by improving end-use technologies in residential, commercial, industrial and manufacturing sectors. In addition to reducing energy consumption and related costs, energy efficiency measures benefit public health by reducing emissions of greenhouse gases and air pollution, and increasing the reliability of the energy grid. By reducing dependence on foreign sources of fuel, energy efficiency also makes an important contribution to energy security.

- An expert report on energy efficiency by the United Nations Foundation (2007) concluded that strategies emphasizing energy efficiency are the most economically and environmentally sensible ways of providing energy for sustainable development and addressing climate change.

- According to the US Environmental Protection Agency (US EPA), state and local government agencies across the US spend more than $10 billion a year on energy to provide

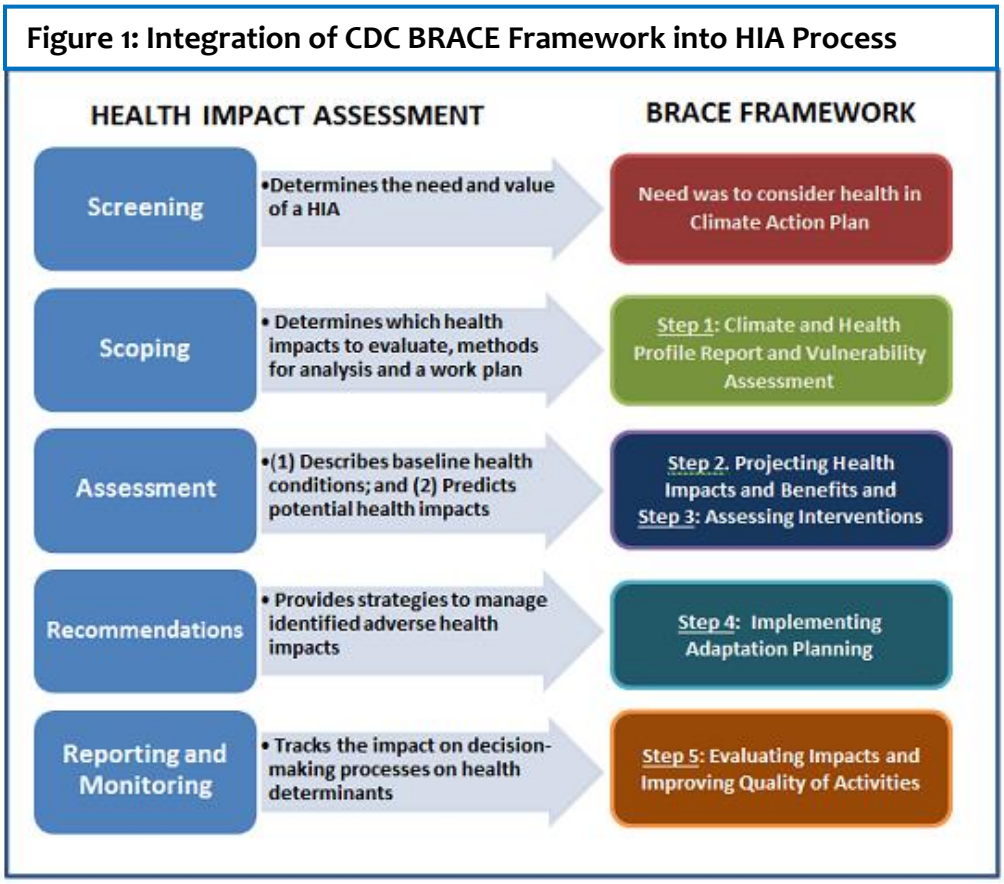
public services and meet constituent needs, but nearly one-third of the energy used by typical government buildings can be conserved.

- Improving the building envelope is a strategy often used to improve energy efficiency by preventing excess heat from escaping, but the potential negative effects on indoor air quality need to consider adequate ventilation rates.

Pathway Diagrams

The goal of a pathway diagram is to visually demonstrate the link between the proposed policy, plan or project and potential health outcomes. Literature reviews and input from the Advisory Committee informed the development of the pathway diagrams. The pathway diagrams illustrate an innovative approach used in this HIA to connect the HIA framework with Centers for Disease Control and Prevention (CDCs) Building Resilience Against Climate Effects (BRACE) framework. The BRACE framework is a five-step process that allows health officials to develop strategies and programs to help communities prepare for the health effects of climate change. Figure 1 illustrates how each step of the BRACE framework was integrated into the assessment phase of this HIA.

Figure 1: Integration of CDC BRACE Framework into HIA Process



Two pathway diagrams were prepared for this HIA: Figure 2 presents the potential health impacts associated with providing cooling centers and other approaches to assist vulnerable populations during heat-related events. The assessment of this pathway focused on projected increases in the frequency and intensity of heat-related events, characterization of vulnerable populations in each community, evaluation of existing heat response plans in each community, and mapping the location of existing cooling centers.

FIGURE 2: PATHWAY DIAGRAM FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS

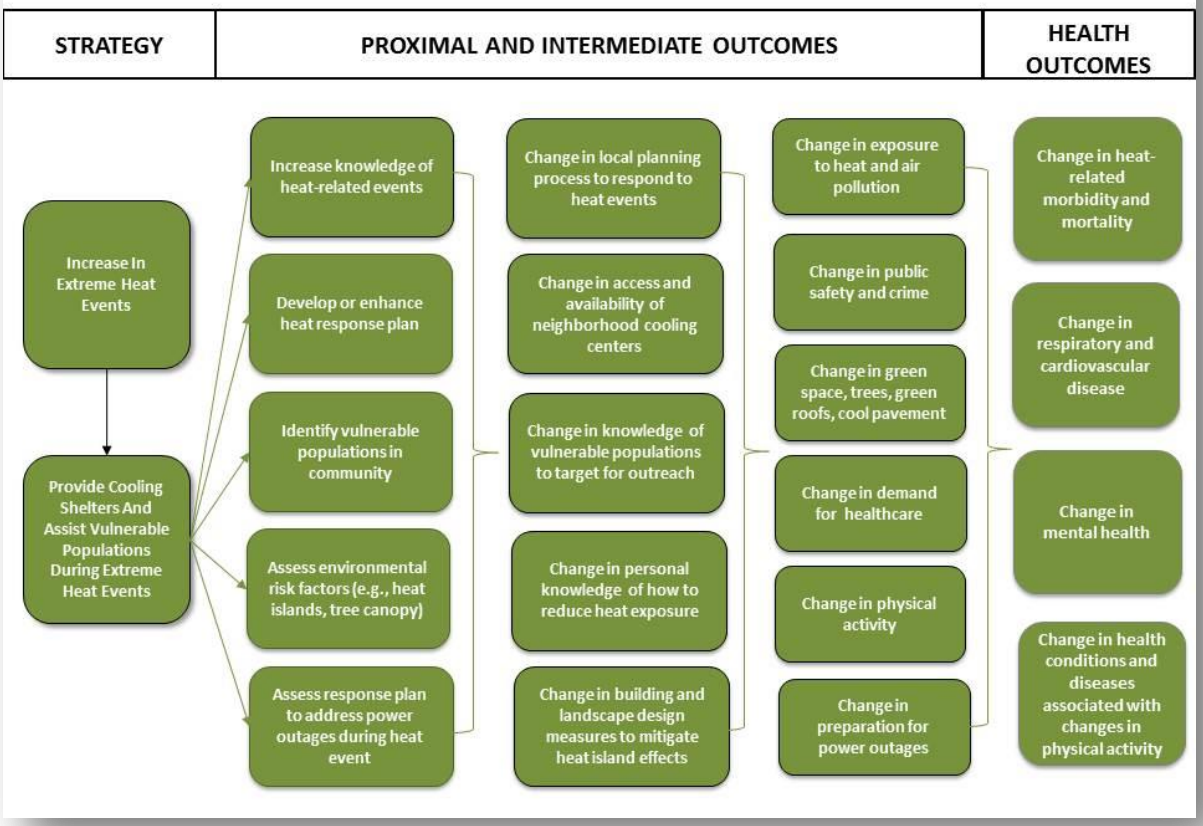
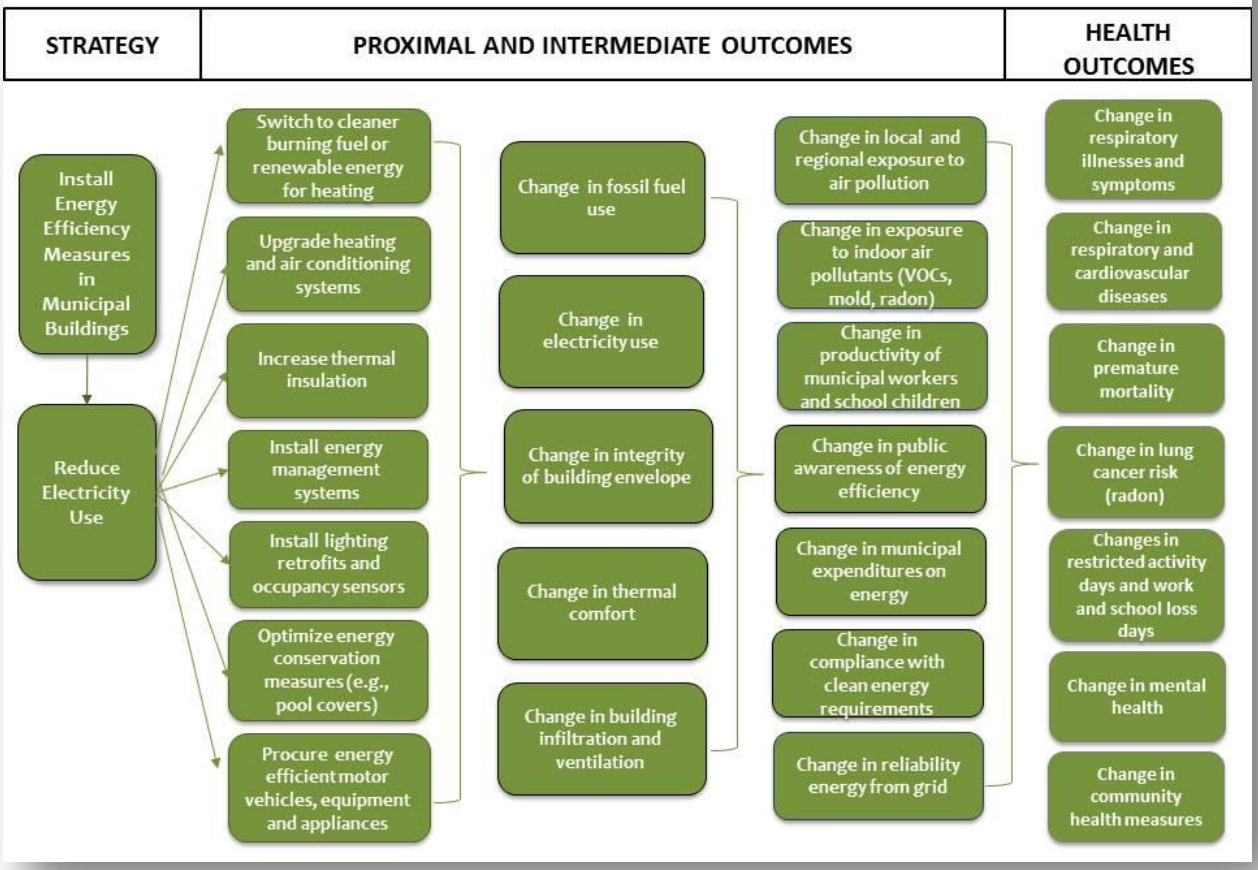


Figure 3 presents the potential health impacts of implementing energy efficiency measures in municipal buildings. In addition to assessing potential climate and vulnerability impacts, the assessment included semi-quantitative analysis of changes in local and regional air pollution emissions from reductions in electricity associated with energy efficiency measures implemented in each community.

FIGURE 3: PATHWAY DIAGRAM FOR IMPLEMENTING ENERGY EFFICIENCY IN MUNICIPAL BUILDINGS



Major Findings of the HIA

- Overall, the HIA found that while designing appropriate research methods for evaluating specific climate action strategies can be challenging, HIAs can be an effective tool to convene municipal stakeholders, evaluate baseline health conditions, and qualitatively assess the health implications of mitigation and adaptation strategies at the local level.

Heat-related Events

- The climate action strategy to provide cooling centers and other approaches to assist vulnerable populations was found to likely reduce heat-related morbidity and mortality.
- For heat-related impacts, baseline health conditions in Springfield (e.g., higher prevalence of respiratory diseases and diabetes in adults, pediatric asthma in children) indicate that the

health co-benefits of this strategy may be substantial. Baseline health profiles in Williamsburg indicate fewer adverse health conditions.

- While there are significant differences in the baseline health profile of Springfield compared to Williamsburg in terms of the number of people in poverty, the number of people of race/ethnicity other than White, and population density, the relative percent of one category of vulnerable residents — elderly living alone (i.e., 1 in 3) — is the same in both communities. Thus, the common issues and resource constraints shared by both a large urban city and a small rural town in developing and activating a heat response plan, including education and outreach to vulnerable populations, as well as taking steps to mitigate environmental risk factors through changes in building and landscape design measures (e.g., lack of trees and green space, impervious surfaces) may be more effectively addressed through regional efforts.

- A key issue raised by stakeholders is the potential loss of power at cooling centers during an extreme heat-related event. Given the regional nature of the electrical grid, this issue should also be considered in future regional planning efforts.

Energy Efficiency

- In addition to cost-savings, energy efficiency programs provide a wide range of health, environmental, and social co-benefits that enhance community resilience.

- Energy efficiency improvements to buildings have positive co-benefits with respect to improving the indoor environment for occupants and reducing outdoor air pollution from the electrical power grid. A US EPA model estimated that the monetized benefits of avoided health impacts of displaced emissions from energy efficiency measures implemented in Springfield ranged from $760,000-$1,700,000.

- While the overall health impacts from implementing energy efficiency measures in municipal buildings are positive, the need to achieve and maintain adequate ventilation for acceptable indoor air quality must also be considered. It is also important to consider the potential increase in indoor radon levels from energy efficiency measures.

- The assessment suggests that energy efficiency measures can increase the productivity of building occupants (e.g., municipal workers and students).

- Energy efficiency activities at the municipal level may also increase public awareness and empowerment to address energy issues and climate change at the local level.

- This HIA demonstrated that although the co-benefits at the municipal level may be relatively small, the total benefits regionally and statewide of such actions are likely to be significant and need to be further assessed.

- A key feature of this HIA is the integration of an evidence-based framework developed by CDCs Climate and Health Program (BRACE) to support the advancement of health-based

climate change adaptation strategies. Evaluation of the approach for integrating the BRACE framework into the appropriate phases of the HIA found that (1) the approach addressed one of the goals of the HIA to collect and analyze evidence between climate change planning and health; and (2) the approach informed the assessment phase of the HIA by providing evidence-based data on climate impacts, health outcomes of greatest concern, and populations potentially vulnerable to climate impacts.

Table 3 and Table 4 provide the overall summary of major impacts, magnitude, severity, strength of causal evidence, assumptions, and limitations/uncertainties of the assessment of climate action strategies evaluated in this HIA.

Impact refers to whether the alternative will improve (+), harm (-), or not impact health or unknown (+/-).

Magnitude reflects a qualitative judgment of the size of the anticipated change in health effect (e.g., the increase in the number of cases of disease, injury, adverse events): Negligible, Minor, Moderate, and Major.

Severity reflects the nature of the effect on function and life-expectancy and its permanence: High = Intense/severe; Mod = Moderate; Low = Not intense or severe.

Strength of Causal Evidence refers to the strength of the research/evidence showing causal relationship between strategies and the health outcome: ♦ = plausible but insufficient evidence; ♦♦ = likely but more evidence needed; ♦♦♦ = high degree of confidence in causal relationship. A causal effect means that the effect is likely to occur, irrespective of the magnitude and severity.

TABLE 3: OVERALL HEALTH ASSESSMENT FOR PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATIONS DURING HEAT-RELATED EVENTS

PROVIDING COOLING CENTERS AND OTHER APPROACHES TO ASSIST VULNERABLE POPULATION						
HEALTH OUTCOMES	**Impact**	**Magnitude**	**Severity**	**Strength of Causal Evidence**	**Assumptions**	**Limitations / Uncertainties**
Change in heat-related morbidity and mortality	+	Moderate	High	♦♦♦	Municipalities will develop/enhance and implement a heat response plan that includes planning for vulnerable residents; and education and outreach on reducing heat exposure during heat events.	Information on existing use of centers is needed; Impact of power outages during heat-related events is unknown.
Change in respiratory and cardiovascular diseases	+	Major	Moderate	♦♦♦		
Change in mental health	+	Unknown	Unknown	♦♦	Municipalities will begin a dialogue about how to address environmental risk factors (e.g., heat island, tree canopy) through changes in building and landscape design measures. Increased physical activity is a co-benefit of these actions.	Insufficient data on mental health effects and future study is recommended. Planning and implementation of design measures is required.
Change in health conditions/ diseases from increased physical activity	+/-	Unknown	Unknown	♦♦♦		

TABLE 4: OVERALL HEALTH ASSESSMENT OF IMPLEMENTING ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS

IMPLEMENT ENERGY EFFICIENCY MEASURES IN MUNICIPAL BUILDINGS						
HEALTH OUTCOMES	**Impact**	**Magnitude of those Exposed**	**Severity**	**Strength of Causal Evidence**	**Assumptions**	**Limitations / Uncertainties**
Respiratory illness and symptoms	+	Moderate	High	♦♦♦	Improved indoor air quality in schools and municipal buildings including compliance with ventilation guidelines.	The magnitude of the outdoor air quality impact from reduced use of heating oil is uncertain.
Respiratory and cardiovascular diseases	+	Major	High	♦♦♦	Reductions in regional air pollution from displaced electricity at electric generating units (EGUs) occur at specified units.	A major limitation of US EPA's model for quantifying benefits of air pollution reductions is that it underestimates total benefits because it only includes secondary formation of $PM_{2.5}$ from NOx and SOx emissions.
Change in premature mortality	+	Major	High	♦♦♦		
Change in lung cancer risk	+/-	Unknown	Unknown	♦♦♦	Indoor radon levels vary across municipalities.	Pre- and post-monitoring is needed. Energy efficiency measures may increase or decrease indoor radon levels.
Restricted activity days and work/school loss days	+	Major	Moderate	♦♦	Increased productivity of workers and students from improvements from energy efficiency measures including improved indoor air quality and lighting.	Surveys are needed. Limited studies from California of post-retrofit benefits in school children; no data on municipal workers.
Change in mental health	+	Unknown	Unknown	♦♦	Improved work/school environment. Public awareness and empowerment to address energy issues and climate change at the local level	Stakeholders provided evidence of positive responses from residents.
Change in community health measures	+	Unknown	Unknown	♦	Shift in municipal expenditures from energy to other uses; increase market value of municipal buildings	Impact of energy efficient buildings on market value of municipal assets is unknown.

Proposed Recommendations:

General Recommendations

- Regions and municipalities statewide without climate action plans should take steps to prepare such plans.

- State, regional, and local agencies should coordinate data and resources to support research and other related activities to improve the understanding of the relationship between climate and health.

- Other climate action strategies recommended in the Pioneer Valley Action and Clean Energy Plan should be examined to better understand health impacts and benefits of climate action strategies.

- Tools, innovative methods, and approaches to conduct comprehensive HIAs should be identified to more fully explore health impacts and benefits of adaptation strategies.

Providing Cooling Centers and Other Approaches to Assist Vulnerable Populations During Heat-Related Events

- Develop heat response plans that includes information about vulnerable populations (e.g., elderly, elderly living alone, socially isolated, children, people without a car, economically disadvantaged); approaches for locating cooling centers that are accessible to vulnerable populations; and personal strategies and solutions for cooling at home during a heat-related event, especially where air conditioning is not available or when the power goes out.

- Implement community-wide mitigation efforts, such as improving building and landscape design standards, promoting an adequate tree canopy and minimizing pavement to reduce urban heat islands.

- Promote regional planning efforts that support consistent educational and outreach materials for vulnerable populations, address environmental risk factors, identify critical indicators (e.g., heat islands, tree canopy), and identify solutions for the potential loss of power at cooling centers during extreme heat-related events.

Proposed Recommendations for Implementing Energy Efficiency Measures in Municipal Buildings

- Ensure that ventilation systems maintain good air quality. Consideration of the Massachusetts Department of Public Health's guideline for indoor air quality will ensure optimal indoor environmental conditions. Specifically, the guideline recommends a ventilation rate of 20 cubic feet per minute (cfm) of fresh air to provide optimal air exchange resulting in carbon dioxide levels at or below 800 ppm.

- The stakeholder process identified the need to better understand and measure community awareness around climate action and how municipal actions can spur empowerment. Changes in public awareness about the value of municipal energy efficiency programs are the cornerstone of state and local government initiatives such as "Leading By Example." One option is to encourage such efforts by increasing resources to support additional energy efficiency programs. This recommendation is supported by a large body of work demonstrating the benefits of incentivizing energy efficiency programs.

- Radon testing should occur prior to and after renovating a building to determine if mitigation measures are warranted and can be incorporated during the renovation. Post-renovation testing should be conducted to ensure mitigation measures were successful.

- Support municipal efforts to apply for Massachusetts Department of Energy Resources (DOER) Resiliency funding to ensure hospitals and other essential facilities have power during outages.

- Support continued state funding of energy efficiency measures at the local level.

- Given that energy efficiency is the most practical policy option to mitigate and adapt to climate change impacts, it is important that the health co-benefits of energy efficiency be promoted at all levels (i.e., individual, municipal, regional and statewide).

Areas of Future Research

- Build on work by the Michigan Department of Community Health's Climate and Health Adaption Program that found evidence that adequate tree canopy has multiple benefits such as decreased heat and air pollution exposure, and increased physical activity. This directly benefits the general population and specifically those individuals with pre-existing diseases including diabetes, hypertension, and obesity.

- Improve the understanding of community awareness around climate actions and how municipal actions can spur empowerment for more system-wide change. This may include strategies that educate residents about the problem, provide information on necessary

behavioral changes to address the problem, promote transparency about sustainability issues, and facilitate consumer's individual choices toward sustainable patterns.

- Poverty and crime are correlated with excessive morbidity and mortality during heat waves. The percentage and number of people living in poverty are much higher in Springfield than in Williamsburg, indicating that the vulnerable population in Springfield is larger. There is also a significant difference in the number of violent crimes in the two communities. Further examination of the relationship between poverty, crime and successful climate adaptation strategies is needed.

- Power outages were identified as a major concern by municipal officials in Springfield and Williamsburg. Analysis of power outages is conducted by the utility industry and consultants. Given that this information would be useful in the planning process, requests should be made for this information at the regional level.

- In addition to the cost-saving, the co-benefits of energy efficiency measures need to be further assessed. For example, there was limited information on the health and performance benefits of lighting retrofits on both school children and municipal workers. In addition, while the US EPA identified possible benefits of removing PCB fluorescent light ballasts, this activity could increase risk if containment and removal actions are inadequate.